My Desktop
Prepare & Submit Proposals
Prepare Proposals in FastLane
New! Prepare Proposals (Limited proposal types)
Proposal Status
Awards & Reporting
Notifications & Requests
Project Reports
Submit Images/Videos
Award Functions
Manage Financials
Program Income Reporting
Grantee Cash Management Section Contacts
Administration
Lookup NSF ID

Preview of Award 1360760 - Annual Project Report

Cover |
Accomplishments |
Products |
Participants/Organizations |
Impacts |
Changes/Problems

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1360760
Project Title:	Development of a Critical Zone Observatory National Office
PD/PI Name:	Louis A Derry, Principal Investigator Timothy S White, Co-Principal Investigator
Recipient Organization:	Cornell University
Project/Grant Period:	05/01/2014 - 04/30/2019
Reporting Period:	05/01/2017 - 04/30/2018
Submitting Official (if other than PD\PI):	Louis A Derry Principal Investigator
Submission Date:	05/10/2018
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Louis A Derry

Accomplishments

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

Organization

The CZO-NO works with the PIs and other personnel from the individual CZOs, the CZO Steering Committee, and NSF. The goals of the CZO-NO are: to provide effective communication within the CZO network and to the scientific community, to aid in developing accessible and useable data resources for the CZO program, provide a point of contact and integration with the international CZO community, initiate and support network level science research themes, and develop education and outreach resources for various instructional levels.

The CZO NO continues to guide communication, collaboration, and network organization of the CZO PIs and Network Executive Committee (NEC). The PI and NEC committees have virtual meetings on a monthly basis. The NO provides a

meeting schedule, agenda, reminders of network-level goals, and combined leadership with the PI committee chairperson. Sharkey records and archives meeting minutes in a Google drive space created for each committee, thus streamlining information exchange across the network. In addition, the NO has internal virtual meetings of the entire staff as well as numerous teleconferences of subsets of the staff, most commonly between co-Is Derry and White

CZO-NO team – meets monthly

Louis Derry, Director and PI (Cornell)

Tim White, Program Coordinator (Penn State)

Sarah Sharkey, Assistant Coordinator, CZO-NO and SAVI programs (Penn State)

Justin Richardson, CZO-NO postdoctoral fellow (Cornell)

Mary Reinthal, Assistant to the Director (Cornell)

Don Duggan-Haas, Education & Outreach (Paleontological Research Institution)

Rob Ross, Education & Outreach (Paleontological Research Institution)

Alex Moore, Education & Outreach (Paleontological Research Institution)

David Lubinski, website design and support (U. Colorado)

CZO PI Committee – meets monthly

Praveen Kumar, chair (Illinois)

Bil Dietrich, chair-elect (Cal Berkeley)

CZO Steering Committee

Gordon Grant, chair (Oregon State and USFS)

Kent Keller (Washington State)

Peter Groffman Carey Institute for Ecosystem Studies

Network Executive Committee (NEC) – meets monthly

Praveen Kumar

Louis Derry

Bill Dietrich

Tim White

Gordon Grant

Subcommittees and lead contacts – report to Director and NEC

- Education and Outreach
  Don Duggan-Haas
- Web site and social media
  David Lubinski, Justin Richardson

- Data managers
  Miguel Leon (University of Pennsylvania)

- Common Measurements
  Louis Derry, Bill McDowell

- Graduate Research Group
  Justin Richardson

A clear need exists to reinvigorate the CZO Steering Committee, and to re-think its role. We have had a number of discussions on this topic internally, and feel that providing the Steering Committee with a modest meeting budget would be advantageous. We would particularly like to recognize Gordon Grant for his unstinting efforts on behalf of the CZO program and the broader community. Gordon has gone above and beyond what any reasonable expectations are in terms of his effort, and continues to provide valuable insight to the CZO program. White has been particularly active in working with the Steering Committee to address these issues.

Similarly CZO NO postdoc Richardson has moved on to a faculty position (UMass Amherst) and will no longer be able to lead the GRG. Identifying and nurturing potential leaders of this effort will be an important task for the next year.

- *Communication and management*
  The CZO-NO has several communication strategy has several aspects. These include internal communication in support of cross network integration, CZO-wide science communication, events at national science meetings, email, newsletter, and social media outreach to the broader Critical Zone science community, development and maintenance of the criticalzone.org web platform, and coordination with the czen.org website.

- *Network organization:*

The NO organizes and hosts regular meetings of the NEC and the PI committee. Each of those groups meets at least monthly using virtual meeting software. Minutes for these meetings are archived in a cloud account accessible to the committee members. The PIs physically meet annually at the CZO annual meeting and site visit, and at AGU each December.

The *E&O team*, which includes NO and other members, meets regularly and maintains working communication using Basecamp software for collaboration. This group comprises 35 members across the CZO network.

The *data managers working group* was established at the behest of the CZO-NO, and has proven quite productive. Rather than expect some outside effort to solve the CZO data issues, it became clear that we needed an internal effort that was much more closely tied to the needs of the users and with realistic goals over the time frame of the current CZO program. The data managers group had monthly virtual meetings through the first half of 2017. In August 2017 the CZO data managers had a physical meeting in Boulder to discuss moving toward a common data management system. This has resulted in substantial progress in defining and addressing data uniformity and compatibility across the CZO system. Data are being vetted, organized in compatible ways, and considerable progress has been made in creating uniform nomenclature for data products across the CZOs.

Another outgrowth of this meeting became a proposal to develop a strategy to move the CZO metadata catalog and some CZO data to the CUAHSI Hydroshare system. An early version of this was discussed at the Annual Meeting in Berkeley, September 2017. With some initial encouragement from NSF a working group of data managers (Collin Bode, Miguel Leon, David Lubinski), CUAHSI Director Jerad Bales and CZO PI Derry began regular meetings to refine the strategy. The process was slowed somewhat by the uncertainty around the Federal budget process, but beginning in January 2018 we were having biweekly meetings. The group uses Trello task management software to track progess, and in April 2018 submitted a Request for Supplemental Funding to support development of a set of data migration tools to move CZO metadata and data to Hydroshare.

CZO-NO beyond April 30, 2018.

The four year grant period for the CZO National Office comes to an end on April 30, 2018. Given the uncertainty over the NSF budget this year, we have been expecting to submit supplemental requests to continue the CZO NO for an additional year. A 1 year No Cost Extension was applied for and granted by the cognizant NSF Program Officer.

PI Derry has indicated a willingness to step down from the day-to-day direction of the CZO NO, and co-I White has agreed to take over those tasks. White has submitted a preliminary Supplemental Request to the NSF PO for continuation of CZO NO operations for the period ending April 30, 2019.

Derry has been working with a group of CZO data managers and CUAHSI staff to develop a process for migrating CZO data and metadata to stable and accessible long term storage in the CUAHSI Hydroshare system. He has submitted a Supplemental Request to the NSF PO to fund this effort for 1 year (more below).

Most of the CZO-NO staff are “soft money”, so it will be important to resolve the future funding issue as quickly as practicable. We understand that circumstances prevented a seamless continuation of funding.

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

Major Activities:

The *data managers working group* was established at the behest of the CZO-NO, and has proven quite productive. Rather than expect some outside effort to solve the CZO data issues, it became clear that we need an internal effort that was much more closely tied to the needs of the users and with realistic goals over the time frame of the current CZO program. The data managers group had monthly virtual meetings through the first half of 2017. In August 2017 the CZO data managers had a physical meeting in Boulder to discuss moving toward a common data management system. This has resulted in substantial progress in defining and addressing data uniformity and compatibility across the CZO system. Data are being vetted, organized in compatible ways, and considerable progress has been made in creating uniform nomenclature for data products across the CZOs.

Another outgrowth of this meeting became a proposal to develop a strategy to move the CZO metadata catalog and some CZO data to the CUAHSI Hydroshare system. An early version of this was discussed at the Annual Meeting in Berkeley, September 2017. With some initial encouragement from NSF a working group of data managers (Collin Bode, Miguel Leon, David Lubinski), CUASHI Director Jerad Bales and CZO PI Derry began regular meetings to refine the strategy. The process was slowed somewhat by the uncertainty around the Federal budget process, but beginning in January 2018 we were having biweekly meetings. The group uses Trello task management software to track progess, and in April 2018 submitted a Request for Supplemental Funding to support development of a set of data migration tools to move CZO metadata and data to Hydroshare.

Meeting organization, 2017-18:

- Data Managers Workshop, August 21-22, 2017
  • Annual CZO Field Meeting, September 9-11, 2017

The annual field meeting was held at the Eel River CZO. The meeting was very successful and additionally allowed the CZO community to further organize and prepare for the November 2016 reverse site visit/network review held in Arlington Virginia. At both, co-I White presented on the status of and vision for Education and Outreach activities of the CZO network.

- All Hands CZO Meeting in Arlington, VA, June 4-6, 2018:

“**Critical Zone Science: Current Advances and Future Opportunities”**

We had 205 attendees, including senior scientists, graduate students, members of Federal agencies, and representation from NGOs.

- AGU Annual NSF - PI Meeting, December 13, 2018
- AGU Town Hall, December 14, 2018

CZO-NO Cross Site Research

Cross site science working groups

The CZO-NO continues to support several cross site science working groups.

The Concentration-Discharge Working Group continues to be active. Some of the ongoing research is described below in the CZO-NO Research section. Initial CZO-NO and SAVI support led to a special issue of Water Resources Research that so far includes eleven published articles based on work from the CZOs and elsewhere, i.e. successfully integrating non-CZO research. PIs Chorover, McDowell and Derry led this effort (Chorover et al., 2017)

Based on the outcome of the Strategic Planning meeting in February 2016, the CZOs joined together and proposed to fund a postdoc to focus on a cross-site network level study of the controls on hydrologic partitioning. This effort received supplemental funding from NSF in 2016, and we undertook a search for a postdoc to lead this effort under the direction of Noah Moloch (Colorado) and Ciaran Harman (Johns Hopkins). Adam Wlostowski began on this project on May 1st.

Hydrologically relevant observations, such as precipitation, streamflow, and meteorology, are commonly made at all CZO sites. Such common-core data sets enable cross-site synthesis research. Ongoing work by postdoctoral scientist Adam Wlostowski investigates how climate and critical zone architecture control how landscapes partition and store water. This work brings together long-term records of precipitation, streamflow, and meteorological data from 15 catchments studied by the CZO network. Partitioning analysis shows that climate is a first-order control on annual water balances. More arid catchments, such as those in Arizona's Santa Catalina Mountains, partition a larger fraction of precipitated water to evapotranspiration. On the other hand, more humid catchments, such as those in Puerto Rico's Luquillo Mountains partition a larger fraction of precipitation to runoff. While this result is unsurprising, this is the first project to clearly map the orientation of CZO sites according to hydroclimatic function. This is an excellent example of how quite straightforward analysis of patterns across CZOs can yield insight not available from the intense study of any single location (see attached figure).

Cross-site studies of elemental cycling.

As part of a cross site project on silica sources and C-Q relationships we identified colloidal transport of Si, Al and Fe as important fluxes at the Boulder Creek CZO in the Gordon Gulch sub watershed. We developed methods based on major element chemistry, XRD, and Ge/Si ratios for identifying colloidal transport of these materials, and showed how they could explain the unusual C-Q pattern for silica in that system. As part of the work on Ge/Si we identified a coal ash contribution to the system, adding further support to evidence for widespread low level contamination of US river systems with coal combustion residues (CCR). We also used Ge/Si data to trace silica sources at the Shale Hills, Southern Sierra, and Jemez basin CZO sites, and carried out field work at the Luquillo COZ in February 2017. We have recently published two papers on colloidal transport and C-Q relations for silica. We have recently extended this work to international CZ sites with collaborators in France, Belgium and Brazil.

This past year, with partial support from SAVI, CZO-NO, NSF EAR 1501271 and ANR (France) the C-Q working group began an effort to recruit and analyze samples across a range of CZOs for variations in silica concentration, Ge/Si ratios, and δ30Si values. Jon Chorover (Arizona) has been curating samples and analyzing then for major and trace elements as necessary. In Derry's lab we have been analyzing Ge/Si ratios. A student of Jenny Druhan's (Illinois) has been working at IPGP, France under the supervision of Jerome Gaillardet, analyzing d30Si. So far, at Cornell we have obtained data from Jemez-Santa Catalina, Boulder Creek, Luquillo and Southern Sierra CZOs. We have also run samples from the LEO hillslope simulator at Biosphere 2 (a project that is supported in part by the SCJ CZO). We are presently in the middle of analyses of samples from the Hakai CZO, British Columbia and the Eel River CZO.

We continue working with gallium – aluminum ratios as a tracer for Al in the environment. Al has only one isotope, and there have not been effective tracers for the behavior of Al in the CZ. We have been developing the use of Ga/Al ratios as a tracer for Al sources and transport. Ga/Al ratios in natural waters are near 10-4 (mol/mol), so dissolved Ga is quite low and analytically challenging. We have developed a method for separating and measuring Ga/Al in water samples at levels ≤ 100 picomolar for Ga, with quantification by isotope dilution. In addition we are developing a database of Ga/Al in rocks, regolith, and plant materials, as well as carried out an initial study of the effect of igneous fractionation on Ga/Al. We were able to use some of our initial results to develop a separate proposal to NSF, now funded under EAR 1660923. Thus the “seed funding” under the CZO-NO project was successful in advancing a novel but untested idea to the stage of a competitive core program proposal.

Specific Objectives: Objectives for the CZO NO this year included:

- Organize and promote interactions within CZO community.
  These include now-routine commincartions such as monthly meetings, newsletters, annual PI meetings. We also sought to expand communication about science using virtual meetings and presentations

- Reach out to the broader CZ science community about the future of CZ science.
  Given that 2018 is the last planned year of the current NSF suported CZO program we believed it was vital to reach out to the broader CZ science community to help define objective snd [arthways to a new CZO program for the next five or more years.

- Develop plan for addressing CZ data issues.
  While data management was not pat of the orhginal charge to the CZO NO it becamse apparent that the NO had to take he lead on this issue in order for it to be addressed in a meaningful way. Yet we had to find path forward that was within the existing budget contraints at NSF EAR.

- Advance Cross site science initiatives.
  In the past year we sought to advance alredy existing cross site science initiatives, such as the Concentration-Discharge effort, as well as enable and promote the effort from new cross site hydrology postdoc by enablking access to CZOs and CZO data acorss the network.

- Reach out to education community about CZ science.
  As we have moved forward with CZ-based science educaiton tools it was inmportant to reach out to the education communiyt at both the secondary and post-secondary levels. We bleive that CZ science is an excellent platform for teaching integrative critical thinking about science and the environment.

- Extend outreach specifically to high URM institutions.
  Historically, engagement of under-represented minority (URM) students in the Earth sciences has been low. We saw an opportunity to reach out to a number of HBCUs that typicaly do not have stand alone Earth science program by highlighting th ecross disciplinary nature of CZ science.

- Enhance international CZ connections.
  We had a unique opportunity this year to develop strong connections between the US adn European CZ science communities. We could also use this opportunity to highlight CZ science to the broader public.

Significant Results:

- Since Ocober 2017 we have had an active working group investigating the needs for a data migration process. This group expanded its initial activity in January 2018 with the addition of Christian Camacho-Colon as a software engineer (undergraduate level).

Camacho-Colon has examined and classified the metadata entries in the criticalzone.org catalog. The data managers group has updated data type names for a large number of fields with the goal of having a moer uniform vocabulary within the CZOs. In most cases we are using selections from the ODM-2 controlled vocabulary list. This list is long, however, and there remains considerable work to do to develop a hierarchical set of vocabulary terms and build the necessary search structure. As an illustrative and very simple example one can consider simple search opaths starting at different entry points:

Chemistry - water chemistry - stream chemistry - chloride

or

Water - stream water - stream chemistry - chloride

The original CZO metadata catalog had approximately 4000 "variables". A script to search for duplicates reduced that number to ≈ 2000. Of those, 1400 were readily assigned to ODM-2 terms. The remaining ≈ 600 require somewhat more hands-on interpretation and we are currently working through that list.

- *Common measurements and data*:

We have moved to a more distributed system for coordinating data between the CZOs. Individual CZO scientists with relevant expertise have been assigned to be lead coordinator for different data sets and or acquisition methods. The lead science coordinators are expected to report to the NEC and PI committees. For example, Roger Bales (SS-CZO) has agreed to take the lead on homogenizing and infilling flux tower data from the CZOs that are acquiring this data. His group developed a self-consistent set of techniques for gap filling, and CZO eddy flux correlation data for ET and now GPP. It makes sense to apply a single algorithm to the different data streams so as to make the data sets as comparable as possible. Other areas of focus to date include subsurface geophysical data, hydrologic partitioning, gas chemistry, stream chemistry, cosmogenic nuclides, and soil carbon. In each case we have one or two individuals who have accepted the charge to lead an organizational effort for both extant data and also issues of compatibility between datasets (i.e., common measurements).

- *CZO Science Rountable*

The recordings of the science meetings are available:

https://www.youtube.com/playlist?list=PLj1oj1_YLcqSJ0qwbOPwZDpHsdayHE74w

- Top down vs. bottom up processes of regolith formation – S. Brantley (SHCZO), W. Dietrich (ERCZO), 10/26/17
- Legacy sediments in the CZOs – D. Richter, S. Billings (Calhoun), A. Anders, P. Kumar (IML), 11/9/17
- Knickpoints – R. DiBiase (SSCZO), J. Willenbring (LCZO), C. Riebe (SSCZO), T. Panicolaou (IML), 1/29/18
- Glacial and periglacial legacy in the CZOs – A. Bettis (IML), S. Anderson (BCCZO), R. DiBiase (SHCZO), 2/26/18
- Disturbance-induced CZ processes – K. Lohse (RCCZO), Goulden (SSCZO), M. Kumar (Calhoun), Bonetti (Calhoun), McDowell (LCZO), 3/26/18
- Hot spots and hot moments – J. Chorover (SCJM CZO), J. Kaye (SSHO), C. O'Connell (Luquillo), A. Bacon (Calhoun), 4/23/18
- *C-Q relations – J. Chorover (SCJM CZO), W. McDowell, A. Wymore (LCZO), L. Derry (CZONO) 5/21/18*

Cross-site studies of elemental cycling.

As reported last year, we are finding an important role for colloidal transport of silica. The data from the Boulder Creek study made clear that colloids could be an important vector for silica, normally assumed to all be in the dissolved form. While the role of colloidal transport has been long recognized for some strongly hydrolyzing metals such as Al, most workers have assumed that silica was largely present as dissolved silicic acid, H4SiO4. At the BC-CZO we found that increase in export of colloidal silica plays a large role in the apparent chemostatic behavior Si in the Gordon Gulch catchment (Aguirre et al, 2017; Mills et al. 2016). We see a similar phenomenon in samples taken from the exit face of the LEO simulator, composed of a 1 x 11 x 30 m layer of crushed fresh basalt that can be subject to controlled precipitation inputs. Initial lysimeter water chemistry analyses indicated that it was very likely that secondary mineral formation was taking place, buffering dissolved solute concentrations. However, because the weathering experiments are so new, overall there are no visible alteration assemblages that can be recognized on the solid phase. Ge/Si ratios in face seep water are much higher than seen in any stream waters other than those strongly impacted by hydrothermal activity (this can cause string enrichment in Ge/Si). The values we obtained (Ge/Si = 7 to 20 µmol/mol) are similar to what we previously observed in bulk analyses of weathered Hawaiian soils. There the secondary soil mineralogy is dominated by amorphous materials such as allophane, imogolite and nano-scale Fe-Al oxides. We infer that similar material is being exported from the LEO simulator, with a preliminary hypothesis that the material is a “proto-imogolite”.

At Luquillo, we are building on earlier work on the granitoid Rio Guaba catchment by extending to the volcanoclastic Bisley catchment. Analyses of samples from the Rio Guaba lysimeter field are quite comparable to those obtain from sampling efforts in the 2000’s (e.g. Derry et al, 2006; Lugolobi et al. 2011). This implies that soil solution chemistry is stable on a decadal time scale. In the Bisley catchment, alteration of a mixed volcanoclastic substrate yields a similar range in Ge/Si ratios but different relationships with Si and Al than found in the granitoid system (*see attached figures*).

CZO NO postdoc Justin Richardson has collaborated with a set of researchers across six CZOs (Calhoun, Southern Sierra, Boulder Creek, Luquillo, Eel River and Shale Hills) to explore trace metals as geochemical signals of processes. Vegetation, soils, regolith, and water samples have been analyzed for their trace metal concentrations. Results show that the Ga/Al ratio of the bulk material generally does not strongly deviate from rock Ga/Al values. However, some surface soils show a strong fractionation in the Ga/Al ratio in the most weathered surface soil horizons. The soil samples were analyzed using a sequential extraction and show a marked difference (nearly 2 orders of magnitude difference) in the Ga and Al partitioning in organic matter bound phase compared to residual rock phase.For gallium and aluminum, we found organic + exchangeable Ga/Al ratios ranged between 0.002 – 0.013 mmol mol-1 and averaged 0.002 ± 0.001 mmol mol-1. Secondary oxyhydroxide Ga/Al ratios ranged widely between 0.2 – 21.8 mmol mol-1 and averaged 7.3 ± 4.3 mmol mol-1. Thus, organic compounds preferentially retained Al while secondary oxyhydroxides preferentially accumulated Ga across CZOs. Both were fractionated relative to fresh bedrock Ga/Al that has ratios near 0.1 mmol mol-1, with the organic and exchangeable reservoirs depleted in Ga and the oxyhydroxide material significantly enriched in Ga. (Richardson and Derry, SSSA and GSA, 2017; Kumpf et al. Goldschmidt 2018; Richardson et al, two papers in preparation).

For mercury, the regolith deeper than surface soils appear to be a large net source or net sink for Hg, depending on the lithology. Surface soils had higher Hg concentrations than the deepest regolith samples, except for Eel River, which had lower Hg concentrations in surface soils compared to regolith. Using Ti normalization, CZOs with < 12 % rock-derived Hg (Boulder Creek, Calhoun, Southern Sierra) had Hg peaks between 1.5 – 8.0 m in depth. At CZOs with > 50% rock-derived Hg, Eel River Hg concentrations and pools were greatest > 4.0 m in the weathering profile while Luquillo

and Shale Hills had peaks at the surface that diminished within 1.0 cm of the surface. Paper submitted: Richardson et al., *Global Biogeochemical Cycles*

Key outcomes or Other achievements:

- *Planning for the Future of CZOs*

A major effort from the CZO-NO was the organization of the All Hands CZO Meeting in Arlington, VA, June 4-6, 2018. The meeting was titled:

"**Critical Zone Science: Current Advances and Future Opportunities"**

We had 205 attendees, including senior scientists, graduate students, members of Federal agencies, and representation from NGOs. The NO prepared a Supplementary Budget which was approved by NSF. The NO worked with the Hilton Hotel to arrange lodging, venue, AV support and meals. The NO developed a meeting information and application website, invited the scientific community to participate via multiple online venues, provided letters of invitation for foreign participants to enable visa applications, and provided partial travel support for 90 participants from across the U.S. The Steering Committee developed the meeting agenda, and NO personnel handled pre- and onsite registrations, managed real time meeting needs, took photographs, notes, handled all expenses, and closed the budget with Cornell University accounting.

A White Booklet summarizing meeting and post-meeting discussion by the community was published Fall 2017: "New Opportunities for Critical Zone Science"; Sullivan, Wymore and McDowell et al.

- *AGU Town Hall December 14, 2017*

Approximately 170 people attended the Town Hall, "Critical Zone Observatories: Platforms for Collaborative Science". Discussion included potential time lines for a new phase of CZO-related cals for proposals, and the proposal to classify CZOs as "community user facilities" versus "investigator driven science projects".

- *Science communications:*

Science webinars

The CZO-NO has hosted a series of science webinars over the past year and a half. The webinars are available for viewing at http://criticalzone.org/sierra/events/cat/webinar/

The CZO-NO organized an all-hands informational webinar to introduce the CZO Strategic Plan to members of the CZO network. Hosts Susan Brantley and Bill McDowell presented "Introduction to the CZO Network Strategic Plan" in August 2016. The webinar is available online: http://criticalzone.org/national/events/event/2016-08-26-intro-to-the-czo-network-strategic-plan/. Since then we have offered a series of webinars on other topics. This was in response to the perception that that PI meetings had little time for discussion of science issues, and there was a strong feeling that we needed a better means of communicating about CZO science among the teams. The goal of these roundtables is to provide a means for CZO personnel to be updated on cross site science initiatives, new and exciting findings, and keep scientific communication and discussion active and current.

2017-18 CZO webinars include

- Critical Zone Services – David Breashears and Jason Field, 3/17/17
- Blue Revolution: Water scarcity in a Changing World – Praveen Kumar, 3/28/17
- Drought Resilience and Water Security – Roger Bales, 4/11/17
- Forecasting of Earth Surface Processes – Jon Pelletier, 4/25/17
- Policy Relevance of Critical Zone Science – Steve Banwart, 5/9/17
- Top down and Bottom up Processes of Regolith Formation - Sue Brantley and Bill Dietrich, 10/26/17
- Legacy Sediments in CZOs - Dan Richter, Praveen Kumar, Allison Anders, 11/9/17

CriticalZone.org website development and use metrics:

Although most of the observatories have their own specialized websites for data serving and other uses, the centralized web presence at CriticalZone.org remains the main website for CZO. David Lubinski continues to be the CZO webmaster, working on design, development, maintenance, and some content. During Year 4, CriticalZone.org continued to have modest, steady web traffic totaling over 205,000 pageviews (see details below). Site visitors are rather engaged, spending almost 3 minutes per session on average. Visits are mostly from the United States (60%). Traffic comes from a multitude of cities, but much of it from the host cities of the individual CZOs (see attached map). Content continues to be regularly added to the Content Management System (CMS) by the 22 web editors who were active in Year 4. The CMS now contains more than 5,700 active entries, including over 2400 publications, 825 people, 735 News Articles, and much more. The structured content has many inter-relationships which tie information together and promote cross-CZO compilations.

The 22 website editors across the CZOs are continuously updating the website. In year 4, they worked on 1300 main pieces of content (i.e. publications, people, news articles, datasets etc). The National Office is an active participant, working mostly on the National pages but assisting with individual observatory pages as well. Sharkey has been particularly active, including posting news stories, opportunities, webinars, and more. Lubinski and others in the National Office assisted with posting content across many of these same areas and others.

Attached graphics illustrate basic information on website traffic to CriticalZone.org during Year 4. All data were gathered via Google Analytics. Monthly values for three key website metrics are plotted below for the period from January 2013 to March 2018.

Highlights of Google Analytics analysis:

Modest web traffic, holding steady

over 205,000 pageviews/yr

over 71,000 sessions/yr

over 48,000 users/yr

Visits from all over the world, mostly the U.S.

U.S. visitors comprised 60% of sessions

U.S. traffic comes from many cities, centered on CZO home cities

Traffic is distributed across most US cities, but not evenly by population. Instead, more traffic comes from cities housing the main universities associated with CZOs, such as State College (PA), Denver/Boulder (CO), Tucson (AZ), and Merced (CA). This uneven distribution at least partly reflects “internal” use by CZOs and their local collaborators.

Phone & tablet use is significant, growing

More than 22% of sessions are via a phone or tablet. The large majority of these sessions are phones (~ 87%). The number of phone-based sessions have increased more than 10x since 2013.

Information in the content management system (CMS) keeps increasing

1300 main pieces of content worked on in Year 4 (i.e. publications, people, news articles etc)

22 active website editors across the CZOs

2400 Publications

535 Current People

290 alumni

735 News Articles

375 Dataset Listings - CriticalZone.org is the dominant access point for CZO data. It stores metadata for more than 375 datasets across most of the CZOs. These datasets link to a total of about 2,000 data files and data web pages. CriticalZone.org enables searching and browsing these data across the network. The actual data values are stored elsewhere, at individual CZOs and domain-specific data repositories (like OpenTopography for LiDAR data).

Top 4 most popular sections

National - Research, Data, Blogs and News.

Observatories - Often some combination of Data, People, Infrastructure, and Publications.

Popular Data types: GIS/map Data, Discharge, Meteorology, Soil Moisture, Soil Temperature, Precipitation, DEM, Chemistry, and LiDAR, snow, tree, vegetation, groundwater, time lapse, hydropedologic, seismic, isotope, snow pit, soil temperature, sap flow, well, and carbon flux.

Common Google search terms - Google search is a significant source of traffic to CriticalZone.org. Listed below are common search terms over the past year that resulted in visits to our website. Also listed are the most common pages they visited. Luquillo CZO shows up more often than expected, probably reflecting Google searches after the hurricanes.

Most common Google search terms (expected):

- czo

- critical zone

- critical zone observatory

- critical zone observatories

- (Names of individual observatories)

- critical zone science

- critical zone definition

Most common Google search terms (unexpected):

- what is leaching

- Saharan dust Puerto Rico

- multiple disciplines

- Puerto Rico gis

- El Verde field station

- how do trees get water

- leaching

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

- *Graduate Research Group*

  CZO Postdoc Justin Richardson has revitalized the Graduate Research Group (GRG) for graduate students. The current membership consists of 148 graduate students from 22+ different academic institutions with direct and indirect connections with the 9 CZOs. The GRG has held 7 virtual meetings over the 12 month period. During these meetings, the GRG discussed professional development materials and opportunities and served as a listserv for transmitting graduate student specific job and fellowship information. The GRG held a formal gathering at the 2017 American Geophysical Union meeting in New Orleans. This fall, the GRG held a monthly virtual seminar with 3 speakers over a one hour period using Zoom virtual conferencing.

- *Speakers*:

  Caitlin Hodges - Shale Hills CZO “Soil moisture vs. anaerobiosis effects on elemental transformations across the landscape”.

  Nicholas Dove - Southern Sierra CZO “Fire and soil biogeochemistry”.

  Zach Brechsisen – Calhoun CZO “Land-use legacies and old-field succession patterns in deep soil CO2 and O2”.

  Justin Richardson – CZO NO “Weathering across CZOs using Ga/Al ratio of Critical Zone materials”.

  Adam Wlostowski – Cross CZO “Hydrology across CZOs”.

  Benjamin Abban – IML CZO “Role of the co-play of land-use and rainfall on water and sediment fluxes at different scales”.

  Alissa White – CJ CZO “Hydrologic and Environmental controls on U and Sr isotopes in the Critical Zone”.

  Ravindra Dwivedi – CJ CZO “Hydrologic functioning of the deep critical zone and contributions to streamflow in a high elevation catchment”.

  Attendance for the GRG webinar series ranged between 11 and 29 individuals.

  As the CZO network transitions into 2019, it will be important to continue providing leadership opportunities and support for graduate students to maintain their ability and interest in participating in the GRG.

- *National Office Education and Outreach Group*

1) **Educational Resource Collection**: The NO E&O group has compiled education activities produced by each CZO and has created a peer-reviewed collection of E&O resources (http://criticalzone.org/national/education-outreach/resources/). Previously, educational resources created by the nine observatories had no centralized dissemination system within the network. Resources are now collected, described with a common set of terms, peer-reviewed, and made available in a searchable, single location.

The collection currently contains 20 resources, with additional activities currently in revision. NO E&O staff have contributed resources to the network-wide reviewed collection with a series of educational activities. In collaboration with the NO webmaster (Lubinski), E&O has designed and implemented a web portal to disseminate these resources to the formal and informal education communities (http://criticalzone.org/national/education-outreach/resources/).

2) CZO Virtual Fieldwork Experiences (VFE):

Virtual Fieldwork Experiences (VFEs) immerse learners in rich visual documentation of field sites, augmented by maps and data, in order to provide science experiences for students that have many of the elements of doing actual fieldwork. VFEs of CZOs’ sites enable students anywhere in the country to visit CZOs, to explore and analyze the nature of the sites and kinds of research data being collected. New work on CZO VFEs has included the following.

- The description of use of VFEs for teaching and learning CZ science was improved. See: http://virtualfieldwork.org/CZO-VFE-Intro.html. This overview includes substantial updates to the Susquehanna-Shale Hills VFE and smaller updates to the Southern Sierra VFE.
- A new VFE for Luquillo has been created (https://prezi.com/0-0bd6recqf_/vfe-luquillo-critical-zone-observatory/). This VFE incorporates the existing collection of digital educational resources created by LCZO E&O staff.
- Shale Hills CZO VFE

Don Duggan-Haas, Sarah Sharkey, Lauren Smith, Siobhan Donnelly, and Sharon Dykhoff

http://virtualfieldwork.org/CZO-VFE-Intro.html

Prezi component:

http://prezi.com/heckentrhf3s/?utm_campaign=share&utm_medium=copy&rc=ex0share

Google Earth kmz file:

http://virtualfieldwork.org/GEfiles/Shale_Hills.kmz

- Southern Sierra CZO VFE

Don Duggan-Haas, Michelle Gilmore, and others at PRI and Southern Sierra CZO.

http://virtualfieldwork.org/CZO-VFE-Intro.html

Prezi component:

http://prezi.com/heckentrhf3s/?utm_campaign=share&utm_medium=copy&rc=ex0share

Google Earth kmz file:

http://virtualfieldwork.org/GEfiles/Southern-Sierra-CZO.kmz

- Luquillo VFE
  Prezi component

- Boulder Creek VFE
  Prezi component [in progress]

- Eel River VFE in development

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

Blogs: Interested lay public, from high school to collegiate educators. The "*Adventures in the Critical Zone*" blog series has continued (J. Richardson), and is hosted on the CriticalZone.org website. The goal of the blog entries is to take complex questions and techniques and 'deconstruct' them to be understandable, entertaining, and informative for general readers. We utilize art illustrated by Alana McGillis and other artists for visually-appealing introductions to science for the lay audience. Popularity of the blogs continues to increase. In the past year, the blogs have averaged about 590 pageviews/month. January 2018 saw 840 pageviews across all blog entries (about 27 pageviews/day).

- Blog entries from April 2017 – April 2018 (live links below).
- What is the Intensively Managed Landscapes CZO?
- Can we see the Critical Zone breathe?
- Making the connection – from the classroom to the field
- Why do we care about suspended matter in water?
- What are clays and do they have a role in the Critical Zone?
- What is the Southern Sierra CZO?
- Modeling the Critical Zone
- What is the Eel River Critical Zone Observatory?
- What are extreme weather events and how do they change the Critical Zone?
- A Tale of Two Dust Specks
- Why should we care about quartz?

CZO Postdoc Justin Richardson also contributed two Critical Zone science posts on the Soil Science Society of America:

1. What is the Critical Zone?

2. What are “boutique” soils? (to be online later this year)

WSKG Public Media Partnership: The CZO E&O group worked in collaboration with WSKG Public Media (in Binghamton, NY) to produce a 3-film series of educational videos featuring CZ science, “Where Rock Meets Life.” These videos are intended to raise the visibility of the critical zone and CZ science for teachers and students who are not familiar with these terms, and similarly for the general public. The videos are destined for PBS LearningMedia (https://www.pbslearningmedia.org/), a widely used resource platform. Filmed at the CZ Observatories and using CZ data, the videos and their accompanying classroom activities take advantage of the expertise of CZ scientists, and emphasize the interdisciplinary nature of work in the critical zone. The first Where Rock Meets Life video titled, “Explore the Critical Zone,” was released on Feb 23, and can be viewed on the WSKG YouTube channel: https://youtu.be/8gW-Vy7zFdU. Films 2 & 3 are in production. These videos are focused on the relationship between rainfall, runoff, and evapotranspiration and on the carbon cycle. We find that even many high school science teachers are not aware of the importance of transpiration in water budgets, and we’re developing video and associated classroom activities to help address this issue. Educational activities have been designed to support the videos, and these are included in the reviewed E&O resource collection.

Professional development workshops for educators:

At educator workshops, resources and activities shared included: a) the National Association of Geoscience Teachers Association’s *In the Trenches* (October 2017); b) Virtual Fieldwork Experiences; c) resources from AGI’s Earth Science Week Toolkits; and d) displays of 3D models of different CZOs. The 3-D models were printed using the TouchTerrain web app (http://touchterrain.geol.iastate.edu/).

Publication for Teachers: *In the Trenches*: A CZ science-themed issue of the National Association of Geoscience Teachers journal *In the Trenches* was published in October 2017. Don Duggan-Haas took the lead in organizing and producing this volume. Articles in the issue included the following:

- Duggan-Haas, Don. “Teaching About the Critical Zone.” *In the Trenches*, October 2017. https://nagt.org/nagt/publications/trenches/v7-n4/index.html
- McGee, Steven, and Noelia Báez Rodríguez. “Getting Students Jazzed About Critical Zone: Engaging Students in Authentic Inquiry Through Data Jam.” *In the Trenches*, October 2017. https://nagt.org/nagt/publications/trenches/v7-n4/index.html
- Moore, Alexandra, Don Duggan-Haas, David Lubinski, and Robert M Ross. “Explore the Critical Zone with the CZO Resource Collection.” *In the Trenches*, October 2017. https://nagt.org/nagt/publications/trenches/v7-n4/index.html
- O’Neill, Katherine P., and Jane F. Rice. “Cultivating a Sense of Place in the Southern Piedmont Using Esri Story Maps.” *In the Trenches*, October 2017. https://nagt.org/nagt/publications/trenches/v7-n4/index.html.
- White, Tim. “Developing a New Transdisciplinary Curriculum in Critical Zone Science.” *In the Trenches*, October 2017. https://nagt.org/nagt/publications/trenches/v7-n4/index.html
- Williams, Jennifer Z., Sharon Dykhoff, Jonathan Pollak, and Susan L. Brantley. “Bringing the Outdoors In: Application of Hydrogeology Education Tools.” *In the Trenches*, October 2017. https://nagt.org/nagt/publications/trenches/v7-n4/index.html.

Critical Zone Observatory comics for K-12, general public audiences

A series of illustrated infographics for each CZO was developed for younger audiences. Each piece has colorful illustrations of land-use histories history and an introduction to the science investigated at each Critical Zone Observatory. These illustrated works convey the geologic setting, ecosystem functions, and anthropogenic pressures present at each CZO. Justin Richardson worked with the Principal Investigators at each CZO to create 10 – 12 panel storylines, which were illustrated by Alana McGillis. Current versions of the CZO comics exist on the “*Adventures in the Critical Zone*” blog series: (http://criticalzone.org/national/blogs/blog/adventures-in-the-critical-zone/).

Presentation of CZO educational resources and findings at professional meetings

CZO-NO staff participated in and made presentations at a series of national meetings at sessions focused on education this year:

- The Geological Society of America (GSA) National Meeting
- NE Regional Geological Society of America
- AGU Fall Meeting

- The AGU-NESTA Geophysical Information for Teachers (GIFT) workshop. (NESTA - National Earth Science Teachers Association)
- Pennsylvania Science Teachers Association Annual Conference
- Science Teachers Association of New York State 122sd Annual Conference
- National Science Teachers Association
- Earth Educators' Rendezvous 2017
- Soil Science Society of America
- SERC webinar on the InTeGrate course, Tim White, February 2017

These conference workshops and presentations directly reached ≈ 400 educators. There were CZO booths at both AGU and Northeast/North Central GSA Meeting, and PRI had a booth at the STANYS meeting (Ross and Duggan-Haas). The Pennsylvania Science Teachers Association's sessions effectively provided a three hour workshop for many of the participants. The New York Earth Science Teachers Association Field Conference also involved work in the field with some discussion of CZ science.

Historically Black College and University education and outreach

In October 2017, CZO-NO postdoc Justin Richardson gave a series of lectures and informal meetings with students and faculty at three Historically Black Colleges and Universities (HBCUs). The goal was to stimulate interest in the geosciences and create a point of contact between students and CZ researchers. Justin Richardson gave guest lectures in an agriculture course for 30 sophomores and quantitative chemistry course for 10 juniors at Virginia State University on October 17th 2017 entitled: "Critical Zone science and the Future of Soil Science". Justin Richardson was the Dr. Booker Juma Seminar speaker for the chemistry department at Fayetteville State University on October 19th, 2017 entitled: "Applications of Geochemistry to Critical Zone Science". Justin Richardson also met with approximately 25 introductory chemistry students regarding the application of chemistry to geology at Fayetteville State University. Justin Richardson visited Norfolk State University on October 20th, 2017 and met with approximately 30 introductory chemistry and 8 physical chemistry students.

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

We plan several changes and seek to define new goals for the next year

The CZO NO leadership will change. Derry will step aside as Director, while current Program Coordinator Tim White will assume the role of Director. Sarah Sharkey will take on the role of Program Coordinator, and Justin Richardson will take on a new role of Outreach and Diversity Officer.

In addition to maintaing the core CZO NO functions described above, below are some of teh new goals for the CZO-NO

1. Continuing to deeply engage LTER (and international) community in the following actions:

i. Organize a CZO/LTER workshop at the upcoming fall 2018 LTER All Scientists Meeting to follow up on progress made at the 2015 workshop and through various meetings including White's participation in LTER workshop in 2017 and ongoing communication with LTER Communications Office Director Davis.

ii. Lead the International Critical Zone Observatory Planning. Committee and an effort to engage the Belmont Forum to fund an international CZO Collaborative Research Action.

iii. Organize and co-lead a joint CZO Science Across Virtual Institutes (SAVI)/ECOPOTENTIAL summer school in July 2018.

iv. Organize and lead the 4th pre-AGU International CZO workshop in Washington in December 2018.

2. Organize a new network meeting in Spring/early Summer 2019*, to include:

1. PIs and other leaders from each CZO and whatever other entities are funded through the new program.
2. Data managers.
3. Half- to day-long seminar at NSF on CZO science and societal relevance.

*Note: no funds are allotted for this purpose, thus to realize this activity a separate proposal and budget will be submitted.

3. Collect assement data across CZOs, including:

a. Create a spreadsheet template to collect yearly statistics from each CZO during reporting periods.

b. Develop methods to quantitatively assess effectiveness and success of NO activities using questionnaires to, e.g., fellowship awardees, workshop participants, and attendees including at professional meeting events.

c. Create a two-page template for a K-12 activity to be completed once per year by each CZO to be edited and approved by the CZO E&O Working Group.

d. Continue to develop a GIS-based assessment of CZ heterogeneity of the U.S. aimed at guiding a strategy for building a “network of networks” (i.e., developing an understanding of how well the CZO, LTER NEON, and other network observatories cover CZ heterogeneity, and determine what major gaps exist.)

4. Continue outreach to education commiunity and specifically HBCUs, including:

a. Participate and attend the National HBCU Conference to prompt discussion about improving connections and access for HBCU students to pursue graduate education in CZ and the greater Earth sciences.

b. Continue to create lesson plans from individual CZOs, AND develop network level content too, by dedicating every other E&O Working Group monthly meeting to creating new resources.

c. Fully implement Virtual Field Experiences for the first three CZOs as a major portion of web content on criticalzone.org.

5. Enhance criticalzone.org website and other virtual communications

a. Focus on improving the CZO integrated website system at criticalzone.org through design, development, and maintenance.

b. Migrate the website to a different Content Management System (CMS) that is more flexible and modern.

c. Redesign the homepage to be simpler and less busy, one that works for scientists and lay people.

d. Re-arrange the website to adapt to ongoing thinking about the future of CZ Science and the CZO network.

Under parallel but separate funding we wil develop a set of data migration tools to bring CZO data and metadata to the CUAHSI Hydroshare system. This effort will include:

1. Migrate CriticalZone.org metadata to CUAHSI Hydroshare
2. Migrate some generic data files to CUAHSI Hydroshare
3. Create a CZO-branded search & discovery tool functioning within Hydroshare
4. Build an entry & editing interface to facilitate easy transfer of data and metadata to Hydroshare now and in the future
5. Initiate an ODM-2 based hierarchical controlled vocabulary structure for CZO data.

This work will involve new and exisiting subcontracts with CZO data managers from Berkeley, Penn, colordado as well as establishment of a formal working relationship with CUASHI. The project is described in more detail in a Request For Supplemental Funding that has ben submited to NSF.

Current NO Director Derry will lead this data migration effort while stepping down as Director of the NO.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
Water balance partitioning across CZOs.pdf	Analysis of water balance partitioning across CZOs by cross-site postdoc Adam Wlostowski.	Louis Derry	05/10/2018
Ge-Si-Al-Fe systematics.pdf	Elemental systematics of Ge-Si-Al-Fe from Luquillo CZO, with contrasting lithologies.	Louis Derry	05/10/2018
E&O figures.pdf	Figures illustrating Education and Outreach activities from CZO NO	Louis Derry	05/10/2018

Filename	Description	Uploaded By	Uploaded On
Google Analytics data from criticalzone.pdf	Graphics from Google Analytics analysis of website traffic at criticalzone.org	Louis Derry	05/10/2018

Products

Books

Book Chapters

Richardson, J B (2017). The Critical Zone. *Encyclopedia of Geochemistry* W. M. White, W. H. Casey., H. Hartnett, B. Marty, H. Yurimoto. Springer Verlag. Berlin. 1. Status = PUBLISHED; Acknowledgement of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1007/978-3-319-39193-9_355-1.

Inventions

Journals or Juried Conference Papers

Ameijeiras-Mariño Y, Opfergelt S, Derry LA, Robinet J, Govers G, Minella JPG, Delmelle P (2018). Increased contribution from deeper mineral weathering to streams after forest conversion to cropland: tracing with Ge/Si.. *Applied Geochemistry*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Campbell SB, Moucha R, Raymo M., Derry LA (2018). Dynamic topography and the Cenozoic carbonate compensation depth. *Geochemistry, Geophysics, Geosystems*. 19 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10. 1002/2017GC007386

Chorover J Derry LA McDowell WH (2017). Concentration-discharge relations in the critical zone: Implications for understanding critical zone structure, function and evolution. *Water Resources Research*. 53 (11), 8654. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2017WR021111

Duggan-Haas D, Ross RM, White T, Moore A, Derry LA (2017). Critical Zone Science is to Science as the Next Generation Science Standards are to Science Education. . *Geol. Soc. America Abstr. Progs*. 183-13. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Grant K, Galy V, Haghipour N, Eglinton T & Derry (2017). Iron loss promotes SOC turnover on a Hawaiian soil gradient. *Goldschmidt Conference of the Geochemical Society*. 11e-3022. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Inagaki TM, Grant K, Müeller CW, Derry LA, Lehmann J & Kögel-Knabner (2017). Distinct soil organic matter properties across a Fe and rainfall gradient. *Goldschmidt Conference of the Geochemical Society*. 11c-004. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

King E.K., Hodges C.A., Chapela Lara M., Aguirre A.A., Foster M.A., McClintock M.M., Richardson J.B. (2017). Metals and metalloids as tracers of Critical Zone processes: A review of established and emerging systems. *International Geology Review*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

McIntosh JC, Porter C, Perdrial J, Harpold A, Vázquez-Ortega A, Rasmussen C, Vinson D, Zapata-Rios X, Brooks PD, Meixner T, Pelletier J, Derry L, Chorover J (2017). Geochemical evolution of the Critical Zone on variable time scales informs concentration-discharge relationships: Jemez River Basin Critical Zone Observatory. *Water Resources Research*. 53 (11), 4169. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016WR019712

Moore A, Duggan-Haas D, Ross RM, Derry LA (2017). Explore the Critical Zone through the CZO network. *Geol. Soc. America Abstr. Progs, Annual Meeting*. 362-2. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Perez-Fodich A. & Derry L. (2018). Basalt weathering and elemental loss under tropical conditions: Effects of CO2, pH and ligands. *Geochimica et Cosmochimica Acta*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer

Reviewed = Yes

Perez-Fodich A & Derry L (2017). Extreme basalt weathering results from high soil CO2, unsaturated conditions and organic acids. *Goldschmidt Conference of the Geochemical Society*. 9c-003. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Richardson JB and Derry LA (2017). Gallium Sorption and Inclusion in Al and Fe Oxides. *Soil Science Society of America Annual Meeting*. 202-3. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Soper F, Chamberlain S, Gregor S, Crumsey J, Derry L, Sparks J (2017). Biological pumping of mineral nutrients in a temperate forested shale catchment.. *JGR Biogeosciences*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

White, TS, AS Wymore, A Dere, A Hoffman, J Washburne, and M Conklin (2018). Integrated interdisciplinary science of the Critical Zone as a foundational curriculum for addressing issues of sustainability. *Journal of Geoscience Education*. 65 (2), 136. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5408/16-171.1

Licenses

Other Conference Presentations / Papers

Other Products

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

Websites

Supporting Files

Filename	Description	Uploaded By	Uploaded On
CZO_2017_White_Booklet_Final.pdf	CZO White Booklet from June 2017 All Hands workshop	Louis Derry	05/10/2018
CZO NO Pubs & Products 2017-18.pdf	CZO NO publications and products text file	Louis Derry	05/10/2018
In the Trenches_featuring CZ science October2017.pdf	In the Trenches CZ science edition Oct 2017	Louis Derry	05/10/2018

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Derry, Louis	PD/PI	2
White, Timothy	Co PD/PI	2

Name	Most Senior Project Role	Nearest Person Month Worked
Richardson, Justin	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Duggan-Haas, Don	Other Professional	2
Lubinski, David	Other Professional	2
Ross, Robert	Other Professional	1
Moore, Alexandra	Staff Scientist (doctoral level)	2
Camacho-Colon, Christian	Non-Student Research Assistant	5
Reinthal, Mary	Non-Student Research Assistant	4

Full details of individuals who have worked on the project:

Louis A Derry
Email: lad9@cornell.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: Led Critical Zone National Office, organized major meeting events, led research in cross site science, led international collaboration with European CZ networks

Funding Support: NSF

International Collaboration: Yes, Belgium, France
International Travel: Yes, Belgium - 0 years, 0 months, 3 days; France - 0 years, 2 months, 0 days

Timothy S White
Email: tswhite@essc.psu.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: Project Coordinator. Organized monthly meetings, led InteGrate course development, planned and hosted pre AGU International CZ workshop, led integration effort with LTER, led efforts with early career researchers

Funding Support: NSF

International Collaboration: No
International Travel: No

Justin Richardson
Email: justin.richardson@cornell.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 6

Contribution to the Project: Richardson is the National Office postdoctoral fellow. He has a major role in developing a social media presence and in diversity efforts. He also is leading a project to investigate controls on the biogeochemistry of aluminum and other metals across several CZO sites. Justin also led efforts to reach out to HBCUs, led and wrote most of the CZ blog entries, the CZ comic series, and the Graduate Research Group

Funding Support: NSF

International Collaboration: No
International Travel: No

Don Duggan-Haas
Email: dugganhaas@gmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: co-responsibility for outreach and education programming, develop VFE modules. Led publication of In The trenches volume, led teacher outreach.

Funding Support: NSF

International Collaboration: No
International Travel: No

David Lubinski
Email: david.lubinski@colorado.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: responsible for web site maintenance and development. Led organization of Data Managers working group, played key role in developing proposal for data migration effort

Funding Support: NSF

International Collaboration: No
International Travel: No

Robert Ross
Email: rmr16@cornell.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: co-responsibility for outreach and education programming, managed Paleontological Research Institution contributions. Participated in CZO-NO presentations at multiple meetings and teacher workshops

Funding Support: NSF

International Collaboration: No
International Travel: No

Alexandra Moore
Email: afm113@gmail.com
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 2

Contribution to the Project: Led effort on educational videos, VFEs and other visual resources. Led development of electronic resources for teachers on criticalzone.org. Led organization of logistics for All Hands workshop in June 2017.

Funding Support: NSF

International Collaboration: No
International Travel: No

Christian Camacho-Colon
Email: ccc266@cornell.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 5

Contribution to the Project: 1. Programming for development of wireless CO2 sensor network. 2. Programming for assessing CZO data and metadata, mapping of variable names onto ODM-2 controlled vocabulary

Funding Support: 2 months CCMR REU Program (summer 2017) 3 months CZO-NO NSF award (2018)

International Collaboration: No
International Travel: No

Mary Reinthal
Email: mcr224@cornell.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 4

Contribution to the Project: assistant to director, organizing meetings, producing newsletter, web site support. Played significant role in organizing logistics for All Hands workshop in June 2017.

Funding Support: NSF

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Institut de Physique du Globe de Paris	Academic Institution	Paris, France
Paelontological Research Institution	Other Nonprofits	Ithaca, NY
Pennsylvania State University	Academic Institution	State College PA
University of Colorado	Academic Institution	Boulder, CO

Full details of organizations that have been involved as partners:

Institut de Physique du Globe de Paris

Organization Type: Academic Institution
Organization Location: Paris, France

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution: The IPGP is participating directly in the concentraiton discharge working group activities. The IPGP is providing samples from French CZOs to US CZ researchers, and at the same time is carrying out silicon isotope measurements on samples from US CZOs as part of this effort. The IPGP is also hosting 2 US graduate students from CZOs as well as one early career CZ scientist and one senior scientist, both from US institutions directly involved in CZO program.

Paelontological Research Institution

Organization Type: Other Nonprofits
Organization Location: Ithaca, NY

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution:

Pennsylvania State University

Organization Type: Academic Institution
Organization Location: State College PA

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Penn State is the major partner institution on this project. NO Program Coordinator T. White is at Penn State. He also coordinates activities for the related SAVI grant (Penn State).

University of Colorado

Organization Type: Academic Institution
Organization Location: Boulder, CO

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?
Nothing to report

Impacts

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

The linkages across and between the US CZOs and also with international CZOs are having impact in the kind of science that is getting done. Cross site comparisons are specific examples, but another is that ideas and methods are being rapidly transmitted among the community. This accelerates the development of ideas and enables broader implementation and testing of hypotheses. We believe that we have developed effective communication strategies across the CZO network, and that this is reflected in the very rapid adoption of new and promising approaches to science and data acquisition across the network.

What is the impact on other disciplines?

Because CZ science is inherently highly cross-disciplinary it is conceptually difficult to draw boundaries around it and define “other” disciplines. Yet, in the space of less than a decade, ideas and techniques that were once the province of single disciplines are now being widely used across several. These include (but are not limited to):

The use of active source reflection seismology to study the 3-D structure of the shallow subsurface. While some of the techniques were developed earlier, the CZO program catalyzed the broad application of geophysical techniques to study the structure of the CZ and integrate the results closely with other kinds of data needed to develop a dynamic view of the CZ.

Developing hydrologic water balances is a well-established approach in watershed hydrology. The CZO program has permitted the systematic application of this approach in a comparative sense across multiple watersheds and climate zones, and this is already showing interesting results.

The challenge of interpreting concentration-discharge relations has a similarly long history on watershed hydrology. At the CZOs, a new combination of water flux data, chemical data, data on biological cycling, reactive transport modeling is providing new insight into this problem, which is neither a hydrologic or geochemical problem alone.

The time- and depth-integrated approach of the CZOs has inspired some other observing networks, such as LTER and DOE, to extend the reach of their observations in a fashion similar to that pioneered by the CZOs. For example, the recognition of the role of “deep” water resources in drought tolerance in California forests had not been enabled by traditional ecological or eco-hydrological methods.

What is the impact on the development of human resources?

Overall the CZO program is training a new generation of scientists who are attuned to the cross-disciplinary nature of the CZ and are fluent with and comfortable working across multiple traditional disciplines. What has been seen as highly interdisciplinary is increasingly viewed as just a routine but essential aspect of CZ science by this younger generation.

We have also made a growing effort to incorporate CZ science into information, materials and tools for teachers at multiple educational levels. For example, CZ science maps on to the Next Generation Science Standards in a very direct way, and provides many opportunities for teachers. We hope that students will increasingly be conversant in the kinds of intellectual challenges that the Critical Zone poses, but also its importance in regulating the proper function of ecosystems and water resources.

What is the impact on physical resources that form infrastructure?

The larger question of how CZO research impacts physical infrastructure is best discussed elsewhere, as the nexus of infrastructure development are the CZOs themselves.

The CZO NO has developed a prototype low cost ($300) field deployable wireless atmospheric CO2 sensor. We are furthering that development and hope to test it on a wider scale in summer 2018.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?

We are building the basis for a long term data archive for the kinds of complex data that CZ science generates. This will be an ongoing project for many years, but we are making a vitally important start.

What is the impact on technology transfer?

New observing systems inspired by CZ science are being brought to market. Feedback between CZ scientists and companies that develop sensor systems is active, with several projects in the stage of patent application.

What is the impact on society beyond science and technology?

We are increasingly seeing the term Critical Zone in popular literature and the press. Sociologist and author Bruno Latour's newest book "Facing Gaia" (Polity Press, 2017) discusses the importance of the concept of the Critical Zone in modern thinking about the relationship between humanity and the environment. Work in the Southern Sierra CZO on snow and water availability in California has had a high public profile. The Critical Zone featured in the Make Our Planet Great Again program from France, and new items with this term appeared in several high profile outlets. The CZO program has effectively introduced a new term into modern discourse about science and people in the environment.

Changes/Problems

Changes in approach and reason for change

The Federal budget uncertainty in 2017-18 impacted plans for the next phase of any CZO program. Since there is not yet publically available plan, the CZOs, including the CZO NO are preparing extensions to current operations that should serve as a bridge to the next phase. It as vital that operations continue, as both hardware and much more importantly personnel need to be maintained to ensure a viable transition. Loss of funding would result in loss of the extensive human capital and expertise necessary to carry out cutting edge science. It would also result in the degradation of physical infrastructure and loss of data.

The delay in preparing proposals, supplements and plans for 2018-19 that was the result of the budget uncertainty should not have a major impact going forward.

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

Nothing to report.

Changes that have a significant impact on expenditures

Accounting errors at Cornell University led to an over-estimation of the finds available for the 2017-18 CZO-NO budget. Until relatively recently we believed that the NO budget would have a carry–forward balance of approximately $59,000 as of April 30, 2018. We now know that this is not the case, and in fact the year 4 budget was overspent and is in deficit. Cornell is responsible for the cost overrun, and no additional costs will be passed on to NSF. Changes are underway at Cornell to ensure this problem does no recur. However, the immediate impact is that we are entering the No Cost Extension period with an effective forward balance of zero.

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.