

[My Desktop](#)  
[Prepare & Submit Proposals](#)  
[Proposal Status](#)  
[Proposal Functions](#)  
[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 - 04/30/2018
Reporting Period:	05/01/2016 - 04/30/2017
Submitting Official (if other than PD\PI):	Louis A Derry Principal Investigator
Submission Date:	04/24/2017
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*

Bill McDowell, chair (New Hampshire)  
 Praveen Kumar, chair-elect (Illinois)

*CZO Steering Committee*

Gordon Grant, chair (Oregon State and USFS)  
 Kent Keller (Washington State)  
 Peter Groffman (Carey Institute for Ecosystem Studies)

*Outgoing members*

Oliver Chadwick (UC Santa Barbara)  
 Jerad Bales (CUAHSI)  
 Kate Maher (Stanford)

*Network Executive Committee (NEC) – meets monthly*

Bill McDowell  
 Praveen Kumar  
 Louis Derry  
 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

There is a need 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

#### 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](http://criticalzone.org) web platform, and coordination with the [czen.org](http://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.

A number of activities focused on the continuing development of cross-CZO network-level collaboration. Foremost among these was the Strategic Planning meeting held in Boulder Colorado in February 2016 that led to the development of a Strategic Plan for the CZO program (<http://criticalzone.org/national/publications/pub/czo-leadership-team-2016-a-strategy-for-advancing-critical-zone-science-feb/>).

The annual field meeting was held at the Reynold's Creek CZO and hosted in Boise Idaho in late September 2016. 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.

The *E&O team*, which includes NO and other members, meets regularly (six times so far in the current academic year) and maintains working communication using Basecamp software for collaboration. This group comprises 35 members across the CZO network.

The *Website and social media* committee comprises seven members, and meets regularly via Basecamp (five meetings, many threads on Basecamp this year).

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. This group uses Basecamp. They have had eight meetings in the last 12 months. 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, stored on CZO websites, but also ported to the CUAHSI HIS (hydrologic information system) using ODM-2.

*Common measurements and data:* We have moved to a more distributed system for coordination 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 area 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).

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

Major Activities:

- Science communications:  
*Science webinars*

The CZO-NO has hosted a series of science webinars over the past year. 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/>

*2017 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

*Graduate Research Group*

CZO Postdoc Justin Richardson has revitalized the Graduate Research Group (GRG) for graduate students. The current membership consists of 46 graduate students from 18 different academic institutions. The GRG has held 6 virtual meetings over the 12 month period. During these meetings, the GRG has set up an informal Peer-Review system, accumulated a professional development material archive, served as a listserv for transmitting graduate student specific job and fellowship information, and a subgroup of 7 members have written and submitted an 89 page geochemical tracer review manuscript (King et al., *in review*). The GRG has also held a formal gathering at the 2016 American Geophysical Union meeting. Thus far, we have achieved the purpose of developing partnerships for graduate students beyond their home institution. In our meetings, we have identified four ways for the graduate research group to increase collaboration and improve professional development.

*Monthly science roundtable*

Given that the focus of the NEC and PI meetings has necessarily been a mix of organizational, reporting, and science, we have decided to implement a monthly CZO science meeting, also hosted virtually. The first of those should occur in May 2017. These will be made available to the wider CZO science community and possibly beyond. 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. The network is large and has many participants and initiatives, and the roundtables will encourage more engagement across the network on shared science issue.

### *Events at national science meetings*

American Geophysical Union Fall Meeting: The NO organizes and implements all logistical operations and financial aspects, and provides support to engage both the CZO Network and greater research community at the 2016 AGU Fall Meeting. This includes preparation of the CZO program booth and all handout materials, booth personnel scheduling, and logistical support for the annual town hall and PI breakfast with NSF. A sticker promoting CriticalZone.org was developed as new promotional material for the CZO booth in 2016. 700+ stickers were distributed. The CZO Booth at AGU provides a high degree of visibility and serves as a central meeting point. The CZO town hall, "Critical Zone Observatories: Platforms for Collaborative Science Tuesday," engaged the research community by an open call for lightning talks on a vision for the CZO network. The nine talks given are listed in the CZO town hall agenda (pdf appended). Approximately 180 people attended the Town Hall.

*Other activities at the AGU and Goldschmidt Conferences:* The CZO-NO provided support for a meeting of the Soil Organic Matter working group at AGU. It also provided support for a Graduate Research Group meeting at AGU and an Early Career and Graduate Student Group meeting at the Goldschmidt Conference of the Geochemical Society in Yokohama, Japan, July 2016.

*Other Critical Zone publications:* The CZO-NO postdoctoral fellow Justin Richardson contributed a revised definition, essential concepts and historical perspective of the Critical Zone and Critical Zone Observatories (Richardson 2017) for the Encyclopedia of Geochemistry, which is Part of the series Encyclopedia of Earth Sciences Series by Springer Publishing.

Specific Objectives: Outreach and social media

### **Social Media** (handle: @CriticalZoneorg)

- Daily tweets are made through CZO **Twitter** @CriticalZoneOrg. The account has produced 1000+ tweets and has close to 600 followers. The audience primarily consists of the greater Earth-surface research community and science news affiliates. Daily tweets receive on average 400-700 impressions (a tweet has been delivered to the Twitter stream of a particular account). Occasional popular tweets can exceed 15,000 impressions.
- **Instagram:** a new account was established to feature the VFEs. @Real.Earth.Inquiry, on Instagram, highlights the diverse landscapes and geo/biological features of the CZOs, and interfaces with our partner organization, PRI, and its Teacher-Friendly Guide series.
- Posts to the CZO **Instagram** @CriticalZoneOrg are bi-weekly. The account has 54 posts and 108 followers made up of graduate students, educators and Earth science enthusiasts. Posts receive on average 20-30 likes. Posts are aimed at featuring CZO graduate students and the concept of CZ science.
- The CZO **YouTube** account features original content from the NO (webinars) and individual CZOs. The account also features CZ-related content from affiliate YouTube channels. 26 videos were collected in 2016 that feature CZ presentations, educational content and news spots.
- **Facebook:** A facebook page '[Critical Zone Observatories - CZO](#)' was started in October 2016. Content on CZO research and opportunities is provided by Richardson

and Reinthal. Lubinski and Sharkey also helped with developing a Facebook strategy and finding plugins to show other social media content directly on Facebook (Twitter, Instagram).

#### *Monthly CZO Newsletter:*

The CZO-NO produces a monthly newsletter for the CZ community, currently distributed to about 300 subscribers, including about 60 from the international community. Not only is the newsletter widely distributed, but data statistics indicate that it is widely read.

**Blogs: Interested lay public, from high school to collegiate educators.** The “*Adventures in the Critical Zone*” blog series has continued from 2015 – 2016, is led by CZO –NO Postdoc Justin 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 for visually-appealing introductions to science the lay audience. Popularity of the blogs continues to increase. In the past 8 months, the blogs have averaged more than 500 pageviews/month.

- Blog entries from March 2016 – March 2017 (live links below):
  1. [Sharing data wealth to make better science](#)
  2. [Why should anyone care about feldspars?](#)
  3. [What is leaching?](#)
  4. [What is the Calhoun Critical Zone Observatory?](#)
  5. [How do people manage carbon in soil?](#)
  6. [What is happening to coastal groundwater?](#)
  7. [How does bedrock influence Critical Zone depth?](#)
  8. [What is the Reynolds Creek Critical Zone Observatory?](#)
  9. [What can the watershed approach tell us about the Critical Zone?](#)
  10. [What is the Santa-Catalina-Jemez River Basin Critical Zone Observatory?](#)
  11. [What is the Susquehanna-Shale Hills CZO?](#)
  12. [What is the Boulder Creek CZO?](#)
  13. [Who does Critical Zone science](#)
  14. [Are all environments part of the Critical Zone](#)
  15. [What is the Luquillo CZO?](#)
  16. [Seeing the subsurface with a sledgehammer instead of a shovel](#)
  17. [What is the Intensively Managed Landscapes CZO?](#)

#### Significant Results:

#### **CZO-NO Cross Site Research**

##### *Cross site science working groups*

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

The initial CZO-NO and SAVI support also led to a proposal to the USGS “*Interconnections Between Hydrologic and Ecologic Resilience*”, and is now receiving USGS Powell Center support (Harpold - UNLV and Sullivan - Kansas are proponents from the CZO program. Burns and Clow are proponents from the USGS). This effort grew directly out of a Cross Site Science Working Group on “Critical Zone Resiliency” funded by the NO SAVI project in 2015.

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 begins on this project on May 1st. He will begin by compiling the available hydrometric data from all critical zone observatories and conducting a preliminary synthesis focusing on broad water balance metrics (mean annual precipitation, rain/snow mix, specific discharge, evapotranspiration). Over the course of Fall 2017/Spring 2018 he will travel to all 9 Critical Zone Observatories and assist each CZO to develop a perceptual model of their critical zone hydrology using a semi-structured template. The perceptual models will be presented together in a review paper comparing them with each other, and with previous perceptual models of hydrology.

While we won't attempt to list them all here, collaborations initiated with the Cross Site working groups and workshops, particularly among the early career scientists have continued to be very fruitful. One that does not directly involve CZO-NO personnel but is a good example of how the early career scientists have come together as a result of the workshops is:

Wymore AS, N West, K Maher, PL Sullivan, A Harpold, DL Karwan, JA Marshall, J Perdrial, D Rempe, L Ma. Growing new generations of critical zone scientists. *In revision: Earth Surface Processes and Landforms (Commentary)*.

*Within the NO group*, we continued research on the sources and cycling of silica and aluminum in the Critical Zone, and the age distribution of organic carbon in soils. Some recent activities and findings include:

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.

We have worked to extend the concept of Ge/Si ratios as an effective "pseudo-isotopic" tracer for silica. While Si has three stable isotopes, Al has only one, and there have not been effective tracers for the behavior of Al in the CZ. We have been developing the use of gallium-aluminum (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  $\leq 100$  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. Postdoc Justin Richardson has obtained and analyzed plant, soil, rock, pore water, and stream water samples from 5 of the CZOs for Ga and Al. Rock and soil samples from Calhoun CZO, Southern Sierra CZO, Boulder Creek CZO, Luquillo CZO, and Shale Hills CZO show that the Ga/Al ratio of the bulk material generally does not strongly deviate from rock Ga/Al values. However, some surface soils, particularly at

Calhoun CZO 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. These results were presented at the Northeastern/Northcentral Geological Society of America meeting in March 2017. Secondary oxide phases of Ga and Al and colloidal/ clay-sized Ga/Al particulates have been separated and will be chemically characterized for soils from the 5 CZOs. Aboveground vegetation samples are being processed to determine the impact of vegetation on the Ga/Al ratio in soil horizons across the climatic gradient of the five CZO being studied. Because of the low concentration of Ga in stream water, two ion exchange column chemistry techniques have been developed to measure Ga, one adapted for solid phase samples, the other for water samples in water samples.

The age and residence time of soil organic carbon (SOC) is an important part of understanding the response of global soils to climate change. Working with Valier Galy (WHOI) and Tim Eglinton (ETH) we have applied a new ramped pyrolysis technique that allows us to obtain a distribution of  $^{14}\text{C}$  ages from a single soil carbon sample. Because soil carbon often represents a complex mixture of components this information is very valuable, as a single  $^{14}\text{C}$  age from a sample is non-unique and thus difficult to interpret. We are currently focused on volcanic soils since they can be very C rich and have SOC with old ages, i.e. long turnover time scales. We find that  $^{14}\text{C}$  ages are strongly correlated with iron loss in heavily weathered basaltic soils from Hawaii. Iron loss itself is a function of precipitation with string threshold effects that appear when soils begin to spend significant time in saturated conditions, favoring microbial Fe reduction.  $^{14}\text{C}$  ages for SOC decrease from ca. 9000 yrs to ca. 2000 yrs as soils become wetter and lose Fe, while over the same increase in precipitation the SOC content increases. The sharply decreased turnover time with increasingly wet and saturated conditions is exactly opposite of what is predicted by standard theory for SOC. These quite novel results point to the importance of carbon interactions with micro- and nano-crystalline Fe-oxides as a much more important control on SOC turnover than the intrinsic stability of SOC compounds. Results from this work were presented at AGU in 2015 and 2016. We expect to be able to extend this approach to some of the CZO sites in the near future, of which Luquillo is likely to be the most similar, with high rainfall, high inputs of SOC, and an active microbial Fe cycle (e.g. work by Whendee Silver and colleagues at the L-CZO).

Key outcomes or Other achievements:

**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](http://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 3, CriticalZone.org continued to have modest, steady web traffic totaling over 212,000 pageviews (see details below). Site visitors remain highly engaged, spending over 3.3 minutes per session on average. Visits are mostly from the United States (69%). 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 25 web editors who were active in Year 3. The CMS now contains more than 4,900 active entries, including over 1900 publications, 730 people, 630 News Articles, and much more. The structured content has many inter-relationships which tie information together and promote cross-CZO compilations.

Website functionality was increased in several key ways during Year 3. Most importantly, we added a Google-powered universal search bar to every page. Searches from National pages show results for any and all observatories. In contrast, searches started from an individual observatory display results for just that observatory. All search results can be optionally narrowed to People, Publications, News, or Events. The search bar is currently used more than 150 times per month.



Another highlight is an updated dataset listing that makes it easier to see standardized topics across the CZOs. This listing was designed in collaboration with the CZO data managers. The combined National listing is located at <http://criticalzone.org/national/data/datasets/> and an example for individual observatory at <http://criticalzone.org/boulder/data/datasets/>. When browsing dataset listings for an individual observatory, the visitor can quickly select a link to see a listing of *all* similar datasets across the CZOs. On a related note, most of the national/data pages were reorganized as well.

The 25 website editors across the CZOs are continuously updating the website. In year 3, they worked on 1400 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.

The website is an ongoing project that requires regular maintenance and attention.

Lubinski keeps the Content Management System running and fixes bugs and other issues. He also supports the 25 active website editors across the CZOs. His support for them varies from providing instructions on updating certain content to analyzing Google Analytics traffic data. It sometimes includes working together on the content itself.

Traffic summary

*Modest web traffic, holding steady*

over 212,000 pageviews/yr

over 67,000 sessions/yr

over 41,000 users/yr

*Users remain highly engaged*

3:21 avg session duration

3.2 pages/session

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

U.S. visitors comprised 69% of sessions

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

Traffic is distributed across most US cities, but not evenly. 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 14% of sessions are via a phone or tablet. The large majority of these sessions are phones (~ 86%). The number of phone-based sessions have increased over 450% since 2013.

*Information in the content management system (CMS) keeps increasing*

(total entries as of 2016-04-15)

1400 main pieces of content worked on in Year 3 (i.e. publications, people, news articles etc)

25 active website editors across the CZOs

1923 Publications

536 People

205 alumni

633 News Articles

342 Dataset Listings - Most dataset listings are composed of more than one component, and even some single entries in the CMS link to complex datasets consisting of 10's to 100's of data files. Thus the 342 CMS dataset listings link to thousands of data files.

### *Popular pages*

(By pageviews)

6% National Home page

2.5% Critical Zone page

0.7 - 1.9% Individual CZO home pages, national Observatories page

Below 0.7% Many different kinds of pages including prominent CZO-hosted meetings, datasets, general info, and opportunities.

### *Top 4 most popular sections*

*National* - Research, News, Data, and Blogs.

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

### *Popular data types*

We looked at traffic and search terms used on CriticalZone.org. These results do *\*not\** include traffic to special data servers hosted by individual observatories.

*Highly Popular:* GIS/map Data, Discharge, Meteorology, Soil Moisture, Soil Temperature, Precipitation, DEM, Chemistry, and LiDAR.

*Popular:* snow, tree, vegetation, groundwater, time lapse, hydrogeologic, seismic, isotope, snow pit, soil temperature, sap flow, well, and carbon flux.

### *Blog is increasingly popular*

The National blog, "*Adventures in the Critical Zone*", was started in 2016 and its pageviews gradually increased for the first ~8 months. Pageviews increased sharply in Sep 2016 and have stayed steady at more than 500 pageviews/month since.

**Pan-CZO email list** - In collaboration with the observatories, we established a system to make it easier to email the hundreds of CZO personnel at one time. The system takes

advantage of email lists already set up at some observatories as well as new lists prompted by this project. The individual observatories continue to maintain lists of their own personnel. And the National Office sends email to all members of all observatories much more quickly. Email is intentionally sent sparingly (about once a month) to help ensure that the messages are actually read.

**Wikipedia entries** - Wikipedia is one of the top results for any general web search about the Critical Zone. So it's important that CZO's perspective and mission are well represented in the appropriate Wikipedia entries. Richardson made substantial updates to [https://en.wikipedia.org/wiki/Earth%27s\\_critical\\_zone](https://en.wikipedia.org/wiki/Earth%27s_critical_zone) and [https://en.wikipedia.org/wiki/Critical\\_Zone\\_Observatories](https://en.wikipedia.org/wiki/Critical_Zone_Observatories)

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

### National Office Education and Outreach Group

E&O Mission: to increase awareness and understanding of Critical Zone science in learners nationwide

In support of the NO E&O mission we have pursued the following initiatives: (1) we have scoured the CZO Network for educational resources and used them to create a reviewed collection that can be promoted and disseminated to learners at all levels; (2) we have created new resources from existing CZO programs and data; (3) we have expanded our social media presence and engaged new partners to improve the visibility of and access to our education projects; and (4) we continued to engage learners through print media, workshops, and professional meeting presentations.

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 have been distributed across the nine observatories in such a way that they are difficult to locate and difficult to use. Resources are now collected, described with a common set of terms, peer-reviewed, and made available in a searchable, single location. The first reviewed collection consists of 16 resources, with a much larger group of additional activities currently in revision or review.

- 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/>).
- NO E&O staff have contributed resources to the network-wide reviewed collection with a series of educational activities:
  - "Introduction to the Critical Zone": grade 9-12 lab activity to accompany WSKG Film series, "Where Rock Meets Life."
  - "Rain and the River": grade 9-12 lab activity to accompany WSKG Film series, "Where Rock Meets Life."
  - "Exploring Your Critical Zone - Applying the Scientific Method to Discover Rock-Soil-Water Interactions": grade 6-8 lab activity
  - Virtual Fieldwork Experience: Luquillo CZO ([https://prezi.com/0-0bd6recqf\\_/vfe-luquillo-critical-zone-observatory/](https://prezi.com/0-0bd6recqf_/vfe-luquillo-critical-zone-observatory/)).

2) **WSKG Public Media Partnership:** E&O is working in collaboration with WSKG Public Media 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>. Film 2 is currently in production. This video has a more specific focus, on the relationship between rainfall, runoff and evapotranspiration. 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.

### 3) 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/](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 VFE

[Prezi component](#)

[Google Earth KMZ](#)

Southern Sierra VFE

[Prezi component](#)

Luquillo VFE

[Prezi component](#)

**4) Professional development workshops for educators:** Workshops were offered in conjunction with Shale Hills REU/RET program, at PRI's Teacher Resource Day, and at several at professional meetings listed below.

- The Teacher Resource Day program (October 1, 2016) at the Paleontological Research Institution's Museum of the Earth, run by Duggan-Haas, Ross, and Moore, featured Justin Richardson providing an overview of CZ science and an activity for soil analysis, and Nancy Coddington previewing WSKG's CZO video series and related resources on <https://www.pbslearningmedia.org/>. Approximately 70 teachers participated.
- Tim White presented a webinar on CZ science to the Portsmouth Virginia school district, an activity he has engaged in twice/year for the past 2.5 years. White also made in-person presentations to the Pennsylvania Science Teachers Association and the AGU GIFT workshop with NO educator Don Duggan-Haas, and CZO RET Lauren Smith. White also participated in nine education and outreach-related telecons in 2016.
- CZO RET Lauren Smith led a secondary education workshop at Penn State in July 2016 on the use of a VFE on CZ science in the classroom and its application to the NGSS. White led 10 participants in a tour of the Shale Hills CZO. 7.5 professional development credits were available from completing the workshop. Smith also presented at the Pennsylvania Science Teachers Association Conference in December 2016.

**5) The Earth Scientist:** A CZ Science themed issue of the National Earth Science Teachers Association's journal, *The Earth Scientist*, was published in Fall 2016. The issue included an editorial and eight articles addressing the teaching of CZ science. Four thousand copies were printed, with roughly 1000 copies distributed to NESTA members, 500 distributed at workshops and share-a-thons the National Science Teachers Association National Conference, and 100 distributed at the American Geophysical Union Fall Meeting. The remaining copies will be distributed at future professional development programming. The issue is also open-source and the [prepublication proof PDF](#) is on CriticalZone.org. The final PDF will be available upon completion at: <http://serc.carleton.edu/nesta/publications/index.html>.

Table of Contents:

- From the President
- From the Executive Director
- Editor's Corner
- Monarchs and the Critical Zone: A New Spin on the Study of Butterflies
- Critical Zone Science and Observatories and Related Education and Outreach Activities and Resources
- Drought in the Critical Zone: Engaging Students in Authentic Inquiry Through Data Jam
- Critical Zone Science, Interdisciplinarity and the NGSS

- Earth Surface Processes in the Critical Zone: An Introductory Course Designed for Teachers
- International Cooperation in Critical Zone (CZ) Science and Education
- Learning from the “Deep Changes in the Land”: The Critical Zone Perspective in Environmental Science Education
- Using Scientist-Teacher Partnerships to Create Student- Driven Environmental Field Research Experiences in Primary and Secondary Education Classrooms

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

**6) Cornell Center for Materials Research outreach and REU students**

- In December 2016, CZO-NO Justin Richardson worked with the Cornell Center for Materials Research and participated in an outreach day with Howard University Middle School for Mathematics and Science. Over two days, Justin Richardson and 5 other Graduate Students and coordinators for Cornell Center for Materials Research engaged with approximately 10 classes of 6 – 8th graders in hands on activities [Justin lead a water purification activity] and Question and Answer sessions about being a scientist. Justin Richardson will participate in the 2017 event.
- The CZO-NO received support for two summer undergraduate research associates through the Cornell Center for Materials Research REU program. One is from University of Puerto Rico, the other from College of Wooster (Ohio). Both will work on CZO related science projects this summer, under the supervision of Derry and Richardson.

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

A series of illustrated infographics about each CZO are being developed for younger audiences. Each piece will be a full color illustrated history and introduction to the science investigated at each Critical Zone Observatory. These illustrated works convey the geologic setting, ecosystem system functions, and anthropogenic pressures present at each CZO. Justin Richardson worked with the Principal Investigators at each CZO to create 10 – 12 panel storylines that were illustrated by Alana McGillis. Current versions of the CZO comics exist on the “*Adventures in the Critical Zone*” blog series. These illustrated CZO introductions were printed and given out as hard copies to attendees at the December 2016 American Geophysical Union Fall meeting.

See an illustrated introduction to the Intensively Managed Landscapes (IML) Critical Zone Observatory, here: <http://criticalzone.org/national/blogs/post/what-is-the-intensively-managed-landscapes-czo/>

and, an illustrated introduction to the Luquillo Critical Zone Observatory, here: <http://criticalzone.org/national/blogs/post/what-is-the-luquillo-czo/> for two examples. The full series can be found at: <http://criticalzone.org/national/blogs/blog/adventures-in-the-critical-zone/>.

**8) InTeGrate Project:** Additional CZO funding was provided through the SERC InTeGrate project for the development of a 15-week upper-level undergraduate curriculum through the SERC InTeGrate project. The course, entitled “Introduction to CZ Science,” has passed through the final external review, and will be live by summer 2017. Co-I White led the development of the course for the past 2.5 years, and recently (February 2017) presented a SERC webinar on the results of the team effort. The team met virtually fifteen times in 2016 to finalize the course and to prepare a manuscript that has been accepted for publication in the March 2017 issue of the Journal of Geological Education.

**9) REU/RET Program:** The REU/RET program, a collaborative initiative between the Susquehanna-Shale Hills CZO and the Stroud Water Research Center, involved substantial organization and preparation in the lead up to the final summer program of the 3-year funding cycle. A final report for this separately-funded program of the NO will be submitted this summer by project PI White. Summer 2016 was considered a success by all who participated (14 undergraduates and 3 K-12 teachers), featuring a 6-day orientation program and culminating in attendance and poster presentations by the REUs and RETs at the biennial meeting of CUAHSI in Shepherdstown, WV. While a renewal proposal to support a multi-CZO collaborative REU program for summer 2017 was not submitted, we are working on one for the following grant year (to be submitted in August 2017).

**10) GEODES Project [NSF-GOLD]**

As an outcome of the NSF-GOLD meeting in 2016, CZO-NO Justin Richardson developed and successfully designed a project with Jason Chen [William and Mary], Andrea Motto [Yale], Carolyn Brinkworth [UCAR], Brian Teppen [Michigan State], Heather Houlton [AGI], Jerlando Jackson [U. Wisconsin Madison], and Dena Samuels [Matrix Center for the Advancement of Social Equity & Inclusion] to utilize interactions with digital scenarios for geoscience departments to learn about unconscious bias and gain behavioral tools to avoid bystander effect. Justin Richardson has leveraged the Graduate Research Group, CZO

Network alumni, and early career scientists to collect participants for interviews to identify incidents of bias and prejudice with the CZO network. Using these interviews, social scientists collaborators will create the experiential simulations that will be used to train faculty on geoscience-specific scenarios in which diversity, equity, and inclusivity are lacking. We will seek CZO faculty as participants in the experiential simulations diversity, equity, and inclusivity workshop to be held in October of 2017. This project has just been funded.

### 11) 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. They include:

- 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 121st Annual Conference
- National Science Teachers Association
- Earth Educators' Rendezvous 2016

These conference workshops and presentations directly reached on the order of 400 educators. Each of the meetings included additional points of contact related to CZ science. This includes most notably participation in three "share-a-thons" at the National Science Teachers Association annual meeting where approximately 300 copies of the CZO-themed issue of NESTA's *The Earth Scientist* were distributed. There were CZO booths at both AGU and Northeast/North Central GSA Meeting, and PRI had a booth at the STANYS meeting with CZO collateral that was largely manned by Ross and Duggan-Haas. The Pennsylvania Science Teachers Association's three sessions were back-to-back in the same room, effectively providing 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.

Presentations by CZO staff on CZO network

CZO Postdoc Justin Richardson has given four invited lectures on Critical Zone science at Brown University, Johns Hopkins, Virginia Tech, and University of Massachusetts Amherst and In each of these talks, the definition of the Critical Zone, location and function of each CZO, types of data collected, links to data, and essential concepts of Critical Zone science were presented.

Tim White: SERC webinar on the InTeGrate course, February 2017

Louis Derry – Plenary address, CRITEX Grenoble, France. May 12, 2017.

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

Nothing to report.

#### Supporting Files

Filename	Description	Uploaded By	Uploaded On
CZO organization chart.pdf	CZO organization chart	Louis Derry	04/24/2017
201-17 web traffic.pdf	Website traffic analysis	Louis Derry	04/24/2017

## Products

### Books

#### Book Chapters

Derry, L A (2017). Germanium. *Encyclopedia of Geochemistry* W. M. White, W. H. Casey., H. Hartnett, B. Marty, H. Yurimoto, e. Springer-Verlag. Berlin. . Status = PUBLISHED; Acknowledgement of Federal Support = No ; Peer Reviewed =

Yes ; DOI: . 10.1007/978-3-319-39193-9\_235-1.

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 = AWAITING\_PUBLICATION; Acknowledgement of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1007/978-3-319-39193-9\_355-1.

White, T., S. Brantley, S. Banwart, J. Chorover, W. Dietrich, L. Derry, K. Lohse, S. Anderson, A. Aufdenkampe, R. Bales, P. Kumar, D. Richter, and W. McDowell (2016). The role of critical zone observatories in critical zone science. *Processes and Dynamics of the Critical Zone: Developments in Earth Surface Processes* 19. Giardino and Houser. Elsevier. The Netherlands. 15. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/B978-0-444-63369-9.00002-1.

## Inventions

### Journals or Juried Conference Papers

Aguirre A Dery LA Mills TJ Anderson S (2017). Colloidal transport in the Gordon Gulch catchment of the Boulder Creek CZO and its effect on C-Q relationships for silicon, germanium, aluminum and iron. *Water Resources Research*. 53 (16), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016WR019730

Chorover J Dery LA McDowell WH (2017). Concentration-discharge relations in the critical zone: Implications for understanding critical zone structure, function and evolution. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Duggan-Haas, D (2016). Teaching Climate Change, Energy, and Critical Zone Science:Developing Optimally Distinct Approaches to Science Education Reform. *Geological Society of America Abstracts with Programs*.. 49 (2), . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1130/abs/2017NE-291265

Duggan-Haas, D. (2016). Critical Zone Science, Interdisciplinarity and the NGSS. *The Earth Scientist*. 22 (3), 15. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Duggan-Haas, D., White, T., Ross, R.M., and Dery, L (2016). Opportunities for Professional Development and Curriculum Support From The Critical Zone Observatory Network. *Geological Society of America Abstracts with Program*. 49 (2), . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1130/abs/2017NE-291265

Duggan-Haas, Don, Lauren Smith, Tim White, Robert M. Ross, and Louis A. Dery (2016). The Shale Hills Critical Zone Observatory Virtual Fieldwork Experience: Using Virtual Fieldwork to Catalyze Actual Fieldwork in K16 Classes. *Geol. Soc. Amer. Abstr. Progs*. 48 (7), . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1130/abs/2016AM-287299

Gilmore, M., Erin S., Meadows, M. and Sullivan, L (2016). Using Scientist-Teacher Partnerships to Create Student-Driven Environmental Field Research Experiences in Primary and Secondary Education Classrooms. *The Earth Scientist*. 22 (3), 28. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Grant KE, Galy V, Dery LA (2016). Thermal reactivity of SOC linked to iron oxide content: Pyrolysis-AMS study of mineral-associated SOC on Kohala Volcano, Hawaii. *AGU Fall Meeting*. B41D-0460. 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 = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

McGee, S., and Rodríguez Báez, N (2016). Drought in the Critical Zone: Engaging Students in Authentic Inquiry Through Data Jam. *The Earth Scientist*. 22 (3), 19. Status = PUBLISHED; Acknowledgment of Federal Support = No ; 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, Dery 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*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Meek, K. Derry, L. Sparks, J. Cathles, L. (2016).  $^{87}\text{Sr}/^{86}\text{Sr}$ , Ca/Sr, and Ge/Si ratios as tracers of solute sources and biogeochemical cycling at a temperate forested shale catchment, central Pennsylvania, USA. *Chemical Geology*. 445 84. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.chemgeo.2016.04.026

Menon, M., and White, T. (2016). International Cooperation in Critical Zone (CZ) Science and Education. *The Earth Scientist*. 22 (3), 11. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Mills TJ, Anderson S, Bem C, Aguirre A, Derry LA (2017). Colloid mobilization and seasonal variability in a semi-arid, headwater stream. *Journal of Environmental Quality*. 46 88. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.2134/jeq2016.07.0268

Moore A, Derry LA (2016). Earth Systems Field Work: Service Learning at Local and Global Scales. *AGU Fall Meeting*. ED13D-0951. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Perez-Fodich A, Walter MT, Derry LA (2016). Understanding the roles of ligand promoted dissolution, water column saturation and hydrological properties on intense basalt weathering using reactive transport and watershed-scale hydrologic modeling. *AGU Fall Meeting*. H51E-1530. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Richardson JB Derry LA (2017). Using gallium as a tracer of aluminum in the Critical Zone: influences on terrestrial cycling from vegetation. *AGU Fall Meeting*. B23E-0623. Status = PUBLISHED; Acknowledgment of Federal Support = No

Richardson JB, Richter DD, Derry LA. (2017). Weathering losses and phase partitioning of Aluminum in the Critical Zone using Gallium/Aluminum ratios. *Geological Society of America Abstracts with Programs*. 49 (2), . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1130/abs/2017NE-291552

Sullivan P, Ma L., West N, Jin L, Karwan D, Noireaux J, Stienhoefel G, Gaines K, Eissenstat D, Gaillardet J, Derry L, Meek K, Hynek, S, Brantley S (2016). CZ-tope at Susquehanna Shale Hills CZO: Testing multiple isotope proxies to elucidate Critical Zone processes across timescales. *Chemical Geology*. 445 103. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.chemgeo.2016.05.012.

White, T, and Duggan-Haas, D (2016). Critical Zone Science and Observatories and Related Education and Outreach Activities and Resources. *The Earth Scientist*. 22 (3), 7. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

White, T. (2016). Earth Surface Processes in the Critical Zone: An Introductory Course Designed for Teachers. *The Earth Scientist*. 22 (3), 22. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

White, TS, AS Wymore, A Dere, A Hoffman, J Washburne, and M Conklin (2017). Integrated interdisciplinary science of the Critical Zone as a foundational curriculum for addressing issues of sustainability. *Journal of Geoscience Education*. . Status = AWAITING\_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Wymore A, White TS, Dere A, Hoffman A, Washburne JC, Conklin MH (2016). Critical Zone Science as a Multidisciplinary Framework for Teaching Earth Science and Sustainability. *AGU Fall Meeting*. ED13E-0954. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

## Licenses

### Other Conference Presentations / Papers

White, T. (2016). *An Introduction to Critical Zone Science*. In Pennsylvania Science Teachers Association Annual Conference. State College, PA. Status = PUBLISHED; Acknowledgement of Federal Support = No

Smith, Lauren (2016). *Critical Zone Science: Creating an Interdisciplinary Approach to Teaching Science in Secondary Schools Using NGSS*. Pennsylvania Science Teachers Association Annual Conference.. State College, PA. Status = PUBLISHED; Acknowledgement of Federal Support = No

Ameijeiras-Marino Y, Opfergelt S, Derry LA, Robinet J (2016). *Ge/Si Ratios Record the Impact of Forest Conversion to Cropland on Soil Chemical Weathering Processes and Solutes Export to Rivers*. AGU Fall Meeting. San Fransisco. Status = PUBLISHED; Acknowledgement of Federal Support = No



Duggan-Haas, Don, Robert M. Ross, and Timothy White (2017). *NESTA and CZO Share: The Critical Zone (CZ): Where Rock Meets Life and the NGSS Meets Your Class!*. In National Science Teachers Association. Los Angeles, CA. Status = PUBLISHED; Acknowledgement of Federal Support = No

Duggan-Haas, Don (2016). *Resources for Learning and Teaching Critical Zone Science*. Earth Educators' Rendezvous 2016. Madison, WI. Status = PUBLISHED; Acknowledgement of Federal Support = No

Duggan-Haas, Don, and Robert Ross (2016). *The Critical Zone: Where Rock Meets Life*. The Science Teachers Association of New York State 121st Annual Conference. Rochester, NY. Status = PUBLISHED; Acknowledgement of Federal Support = No

Duggan-Haas, Don (2016). *The Nuts and Bolts of Doing Earth and Environmental Science Fieldwork: Studying the Critical Zone*. Pennsylvania Science Teachers Association Annual Conference. State College, PA. Status = PUBLISHED; Acknowledgement of Federal Support = No

White, Timothy, Don Duggan-Haas, and Sarah Sharkey (2016). *The Shale Hills Critical Zone Observatory Virtual Fieldwork Experience: A Gateway to the NGSS's Three Dimensional Science*. AGU - NESTA Geophysical Information For Teachers (GIFT) Workshop 2016. San Francisco. Status = PUBLISHED; Acknowledgement of Federal Support = No

Duggan-Haas, Don (2016). *Using the Science Literacy Documents to Guide Instruction*. Earth Educators' Rendezvous 2016. Madison, WI. Status = PUBLISHED; Acknowledgement of Federal Support = No

## Other Products

### Other Publications

White, Tim, and Sharkey, Sarah (2016). *Critical Zone*. in Oxford Bibliographies in Environmental Science. (Ed., Ellen Wohl) New York: Oxford University Press. Status = PUBLISHED; Acknowledgement of Federal Support = No

## Patents

## Technologies or Techniques

## Thesis/Dissertations

## Websites

## 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
Richardson, Justin	Postdoctoral (scholar, fellow or other postdoctoral position)	11
Duggan-Haas, Don	Other Professional	2
Lubinski, David	Other Professional	3
Ross, Robert	Other Professional	1
Moore, Alexandra	Staff Scientist (doctoral level)	2
Reinthal, Mary	Non-Student Research Assistant	2

**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:** PI and project director**Funding Support:** NSF**International Collaboration:** Yes, United Kingdom**International Travel:** Yes, Japan - 0 years, 0 months, 6 days

---

**Timothy S White****Email:** tswwhite@essc.psu.edu**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 2**Contribution to the Project:** co-I and Program Coordinator**Funding Support:** NSF**International Collaboration:** Yes, United Kingdom**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:** 11**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.**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**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:** 3

**Contribution to the Project:** responsible for web site maintenance and development

**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

**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

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

---

**Mary Reinthal**

**Email:** mcr224@cornell.edu

**Most Senior Project Role:** Non-Student Research Assistant

**Nearest Person Month Worked:** 2

**Contribution to the Project:** assistant to director, organizing meetings, producing newsletter, web site support

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

---

#### **What other organizations have been involved as partners?**

<b>Name</b>	<b>Type of Partner Organization</b>	<b>Location</b>
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:**

---

**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?**

Nothing to report.

**What is the impact on other disciplines?**

Nothing to report.

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

Nothing to report.

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

Nothing to report.

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

Nothing to report.

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

Nothing to report.

**What is the impact on technology transfer?**

Nothing to report.

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

Nothing to report.

---

**Changes/Problems****Changes in approach and reason for change**

We have increased our efforts in leading the CZO group to address issues laid out in the Strategic Plan and the Reverse Site Visit. These include data organization and accessibility, a clearer approach to developing, vetting and publishing educational resources, and a new series of webinars and science discussions designed to enhance cross CZO research and collaboration.

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

Nothing to report.

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

Nothing to report.

**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.