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## Preview of Award 1360760 - Annual Project Report

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### Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	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 - 04/30/2020
Reporting Period:	05/01/2018 - 04/30/2019
Submitting Official (if other than PD\PI):	Louis A Derry Principal Investigator
Submission Date:	05/26/2019
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Louis A Derry

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### 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

- 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 progress, 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: **Data migration to Hydroshare.** We began a significant effort move CZO metadata and data from criticalzone.org to Hydroshare. Criticalzone.org was never intended to provide term data storage. Each CZO has its own data system, with links from the metadata catalog at criticalzone.org. There was no controlled vocabulary for CZO data, each site developed their own. Major activities this year have included an assessment of CZO data quantity, data types, and data organization, followed by the development of a controlled vocabulary. This in turn enabled the migration of extensive CZO

Specific Objectives: **Controlled Vocabulary:** Develop a controlled vocabulary for all CZO data. Utilize existing ODM2 terms when applicable, and request new terms from ODM2 when necessary. Parse existing CZO datasets and assign new ODM2 vocabulary. Check for errors and mis-assignments.

**Metadata migration:** Export the CZO metadata catalog from criticalzone.org to Hydroshare. Develop migration tools, test, modify as necessary.

**Partial data migration:** Copy available CZO flat files to Hydroshare. Develop migration tools, test, modify as necessary. Not all CZO data can currently be moved or copied to Hydroshare. Some types of data (e.g. LiDAR) are not well suited for Hydroshare and have other storage options available. Some data is stored by CZOs in relational databases and must be exported with tools specific for that database before it can be migrated. That is a larger task for which we did not have time or resources in this cycle.

**Modify HydroShare to meet CZO's needs for administration and search/browse.** Although HydroShare's administration/access system and discovery mechanisms are already quite developed, CZO requires several critical and substantial modifications. A new hierarchical administration/access structure is needed so that all 10 observatories can be explicitly tied together into one CZO community. Customization of the Discovery/home page is needed so that CZO's users can search/browse just the CZO data resources and choose CZO-specific filters (e.g., observatory name).

**Develop and maintain liaison with the Clowder data management project.** The Clowder project is a major NSF effort to develop and deliver tools for working with diverse data sets in the sciences. We wanted to ensure that the CZO and CUAHSI efforts could be integrated with Clowder, and so established regular communication with the Clowder team.

Significant Results: We have mapped 4,279 variable names from the uncontrolled list to a consolidated list of only 443 standardized ODM2 variable names. In the process, 208 new variable names with full definitions, were created and will be submitted to the ODM2 vocabulary maintainers. This transformation of uncontrolled terms into a much shorter controlled list will enable easier cross comparison of data collected at different CZOs and will facilitate easier data discovery.

At the early stages of this project, we built a script to export all metadata from CriticalZone.org into a comma-separated value (CSV) format that can be ingested into

HydroShare. We upgraded the script in February 2019 so that exports could be generated anytime, without needing human intervention. Through intensive, iterative discussions with CUAHSI, we have mapped more than 40 of the most useful metadata fields and subfields in the CSV export to their closest equivalent fields in Hydroshare. About 60% of these mapped fields will be used for new HydroShare datasets; the remaining fields are being archived with the migrated datasets to ensure that no information is lost during the transition. This CZO data effort has examined the full range of metadata variability of datasets in CriticalZone.org and made a variety of changes to streamline the types of data and associated metadata to improve searching and discoverability.

The powerful migration tool already built by CUAHSI to handle *metadata* (as discussed above) also imports *data files*. Each of the test migrations have harvested >3100 data files (totalling > 20 GB) from across the CZO network and successfully imported them into HydroShare. These "generic" data files include comma or tab separated values, Excel spreadsheets, PDFs, KMLs, metadata texts, zip archives, and other files with a known format. Some testing has been completed to verify that the files have been migrated properly, and additional testing is currently ongoing.

With CZO feedback, CUAHSI has also added new functionality to HydroShare that enables the tracking of URLs that link to data that is not available as files. In many cases, these links are to web pages that either themselves point to data files or have web interfaces enabling data files to be extracted "on the fly" from relational databases. Each of the HydroShare test migrations have harvested >600 URL links. The links include data management systems hosted by individual CZOs as well as by non-CZO organizations such as OpenTopography.org (LiDAR data), USGS (e.g., stream gauges), Ameriflux (e.g., eddy flux covariance) and others. The new HydroShare link-related functionality creates "Reference Files" for a data resource that lie alongside regular files in the content section. These aren't traditional files; instead they are essentially URLs combined with additional metadata. This improvement to HydroShare has been made on behalf of several groups including CZO, but will benefit the entire HydroShare user community.

With CZO input and feedback, CUAHSI has already made substantial progress in expanding the administrative and access capabilities of HydroShare to accommodate CZO's needs. A new functionality called "Communities" has been created. It enables grouping of data resources by individual observatories as well as by an overarching CZO organization. HydroShare was originally designed around individuals and groups. Adding the overarching Community structure is a substantial redesign of the system. As part of the communities functionality, a new user role of community manager has been developed. These managers will be able to make edits to any CZO HydroShare resource. Each CZO will also have a manager who can verify that resources for their observatory meet CZO's standards before they are made public. After extensive testing with CZO, Communities functionality will be offered to other organizations.

Clowder representatives were regular attendees at eh weekly to biweekly planning meetings with CZO and CUAHSI personnel as we developed a data strategy. Clowder has already begun to developed tools for working with CZO data, and we plan a test case involving data from multiple CZOs in the summer of 2019. Clowder can provide the kinds of software functionality to help work with multiple datasets across multiple CZOs now that we have developed a controlled vocabulary for CZO data.

Key outcomes or Other achievements:

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

The CZO data project employed and trained undergraduate Christian Camacho-Colon in 2018. He was a computer engineering student at Inter-American University (Bayamon, PR) who had worked with the CZO-NO in summer 2107. His

education was interrupted by Hurricane Maria, and we brought him back to Cornell University from January – June 2018. He worked with the data team to characterize CZO data sets and to develop controlled vocabulary.

The CZO data team has held meetings with CZO data managers and PIs to inform them of the direction and progress of the Data Migration project, to provide initial training on work needed to enable this transition, and to set out expectations of each of the individual CZOs for this overall goal.

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

Provide logistical and technical assistance for CZO-related conferences, workshops, meetings, telecons and webinars. This includes weekly reminders, meeting minutes and technical support for monthly CZO committee meetings including the Network Executive Committee, and both business and science meetings of the PI Committee.

- Maintain National Office Google Drive and Calendar for internal meetings, conferences and presentations.
- Write and distribute quarterly newsletter *CZNews* via e-mail that highlights CZO network efforts, outreach by the National Office, international CZ science and a CZO research spotlight. A monthly newsletter with opportunities is distributed in interim months.
- Produce and post weekly content to CriticalZone.org under the opportunities, news and event sections. The NO effort endeavors to collect, post and promote CZ science related sessions, presentations and workshops made at various conferences.

- Co-organize and oversee CZO program national presence at AGU including 4th pre-meeting international workshop, science poster presentation by me, program booth in exhibit hall, town hall, and annual breakfast with NSF

- Logistics and technical assistance for CZO Town Hall including compilation of network-wide statistics for this presentation.

- Logistics and technical assistance for CZO PI Breakfast held December 12th.

- Exhibitors for CZO booth, responsible for producing CZO agenda and other booth materials for distribution.

- Responsible for making CZO presentation agenda and additional booth materials.

- Propose, lead, and present in CZ session entitled “Critical Zone Processes, Function, and Resiliency: Challenges and Opportunities at Northeast regional meeting of the Geological Society of America, Burlington, VT

- Attended CUAHSI Biennial meeting 29 July- 1 August in Shepherdstown, West Virginia to represent National Office and SAVI project, and to present network poster.

- Creation of 4 comics that illustrate how scientists approach and conduct CZ science. The comics focus on Drs J. Druhan’s CO<sub>2</sub> work at Eel River CZO, J. Richardson’s trace metal work across the CZO network, R. Dwivedi’s river chemistry work at Catalina-Jemez CZO, and R. Lybrand’s fungal-mineral work at Catalina-Jemez CZO. The text reads at a 9th grade level on the Flesch-Kincaid Grade Level test and include illustrations of how CZ science moves from concept to data and answering the initial question.

- Proposed and led a CZ focused session entitled “Role of Soils in Mediating the CZ” at the 2019 Soils across Latitude annual meeting of the Soil Science Society of America, held jointly with the Mexican Society of Soil Science and the Canadian Society of Soil Science in San Diego, CA. The session included presentations by 4 early-career women scientists (Drs. J. Druhan, N. West, J. Willenbring, R. Lybrand.

- Communication and meetings mostly within immediate CZO community but also with other US-based environmental networks:

- Five calls and many emails with LTER national office director Frank Davis to develop, write and submit an unsuccessful NSF RCN proposal.
- Eight phone conversations with NSF program officers
- Eight Zoom conferences with CZONO staff
- Eleven CZO PI committee webinars
- Eight CZO Science presentation/discussions
- Nine CZO Network Executive Committee webinars
- Four teleconferences with Don Duggan-Haas, CZONO E&O staffer, to reorganize CZO E&O activities and strategies
- Five face-to-face meetings with Janet Swim, Penn State professor of Environmental Psychology, to develop alternative social sciences presence in the CZO community
- One meeting with Penn State Geosciences faculty Peter LaFemina, to discuss a potential role from a CZ perspective in his internal/Penn State funded project to develop general education learning tools
- Two webinars and one face-to-face meeting with U Alaska-Fairbanks faculty to describe CZOs, etc., to help them potentially develop a CZO proposal in anticipation of upcoming RFP.
- Seventeen telecons/webinars with CZO early career researchers to support their various efforts and in two cases, to co-write a paper that remains in preparation
- Three meetings with Doug Miller, Jim Sloan, Sarah Sharkey, Penn State faculty and staff, and a student, to develop a GIS approach to evaluating CZ heterogeneity nationally for the purposes of evaluating the geographic effectiveness, and potential for linking, observatories from various environmental networks – in progress.
- Four webinars as follow up to workshop conversations at AGU aimed at societal relevance of CZ science
- Three telecons with Zion Klos to organize an ongoing effort to evaluate Site Seeker and write a descriptive manuscript
- Two telecons with Dave D'Amore, USFS soil scientist, Heen Latinee Experimental Forest, Juneau, AK, to discuss their efforts to develop the site as a CZO
- Two webinars through SERC InTeGrate to discuss and promote Introduction to CZ Science course, proposed and led by co-I White, and completed in past years
- Two meetings with Paul Shrivastava, PSU Sustainability Officer, to discuss approaches to Belmont Forum, availing of his pre-PSU directorship of Future Earth
- Two telecons with NSF to discuss development of international CZ science funding initiative through Belmont Forum
- Two calls to begin organizing NSF IUSE proposal, ongoing, to be submitted in coming month
  - Social Media (handle: @CriticalZoneorg)
- Daily tweets are made through CZO Twitter @CriticalZoneOrg. The account has produced 2,400+ tweets and has +1,190 followers. The audience primarily consists of the greater Earth-surface research community and science news affiliates. Daily tweets receive on average 500-800 impressions (a tweet has been delivered to the Twitter stream of a particular account)
- Posts to the CZO Instagram @CriticalZoneOrg are typically bi-weekly. The account has 98 posts and +325 followers made up of graduate students, educators and Earth science enthusiasts. Posts receive on average 35-50 likes. Posts are aimed at featuring CZO graduate research and the concept of CZ science.
- The CZO YouTube account has 40 subscribers. It features original content from the NO (i.e. webinars) and individual CZOs. The account also features CZ-related content collected from affiliate YouTube channels.

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

We have submitted a Supplemental Funding request with two main goals for the 2019-20 period. The principle goals for the Supplemental request are to: 1) support the ongoing integrative organizational, research, education and outreach goals of the Critical Zone Observatories National Office (CZO-NO); and, 2) lead development of a data system for CZO data, in collaboration with CUAHSI. This second goal was not originally part of the purview of the CZO-NO, but it became clear over time that the NO could play a key role in developing this very important capability for the CZO program.

For part 1, planned activities include:

- 1) Reinitiate and energize monthly CZO community science webinars, pressing discussions toward societal relevance and solutions to problems while continuing to embrace basic science.
- 2) Continue to deeply engage the broader Earth surface and environmental science community, including internationally, through continued collaboration and communication with the LTER Communications Office (results of two workshops in 2015 and 2018 are summarized in Richter et al., 2018; a series of jointly-led workshops was proposed in a Research Coordination Network proposal submitted in Fall 2018), the National Ecosystem Observation Network (NEON), U.S. Forest Service Experimental Forests and Range program, and other relevant federal agencies and programs; leadership, planning and participation in developing a “soils and water within a CZ framework” Collaborative Research Action through the Belmont Forum (proposal in development); leadership of a second Critical Zone and Ecosystem Dynamics summer school in Italy in July 2019 through support from the CZO SAVI project and the European Community-funded ECOPOTENTIAL project; and, leadership of the 5th pre-AGU International CZO workshop in December 2019.
- 3) Reorganize early career researchers as a working group with ties to the CZO Graduate Research Group, to provide a collaborative venue and voice for the next generation of CZO researchers (e.g., Wymore et al., 2017).
- 4) Organize a cross-CZO effort to contact land managers and federal agencies associated with state and national land within a CZO host state and/or adjacent to a CZO to educate and inform them of relevant science and the CZ concept.
- 5) Continue the international cross-CZO work on concentration-discharge (CQ) relations in the CZ (see Chorover et al., 2017 on special issue of *Water Resources Res*). This project was initiated with a combination of funds from CZO-NO, SAVI, NSF grants to several CZO PIs, and ANR (France). Currently the project is generating data on hydrologic event samples from four U.S. CZOs (Boulder, Jemez-Catalina, Southern Sierra, Luquillo), the experimental LEO observatory at Biosphere 2, and four international CZOs (Lhozere, OZCAR-France; ObSERA Guadelope, OZCAR-France; Kabini, India; and Hakai, BC Canada). At the same time we are developing new approaches for modeling non-steady state hydrogeochemical systems, including virtual, reactive and non-reactive tracers (e.g. Marcais, Harman and Derry, 2019; Druhan et al., 2019). We plan to continue this very successful international effort this year, again leveraging funds from multiple sources. The modest budget from the CZO-NO plays a key role at the center of this effort.
- 6) Develop a strategy for and organization of a new CZO network meeting in 2019-20, supported by a separate proposal and budget, to include: PIs, data managers, and other leaders from each CZO and other entities funded through the new program; crafting a new strategic plan to guide collaborative cross network activities that evolve from known commonalities in each CZO's research questions, and focus on societal relevance and environmental sustainability.

For part 2 (Data Management) we list some of the specific targets for the next year.

Development of a Controlled Vocabulary:

Submit 208 new Variable Names into the ODM2 controlled vocabulary.

Add definitions and other metadata to 74 existing Variable Types.

Submit 74 Variable Types into the ODM2 controlled vocabulary.

Track new Variables associated with new datasets entered at CriticalZone.org *before* the migration to HydroShare is completed.

Metadata Migration:

The results of test migrations have been largely successful but we have identified some particular areas that need additional attention and clean up. These include:

- Modifying authors listed on datasets to a more uniform, parsable format.
- Updating or removing URL links to data that were incorrect.
- Updating locations with more accurate latitudes and longitudes
- Continue testing metadata migration from CriticalZone.org to HydroShare, until all systemic errors are fixed.
- Fix individual errors that may appear as new records are added to CriticalZone.org before final migration.
- Work with IML CZO on creating compatible metadata (IML has a custom database)
- Test the migration of IML CZO metadata.
- Conduct a final migration of CZO metadata from CriticalZone.org to the live HydroShare instance at HydroShare.org (instead of to test servers).
- CZO Data Managers - check and validate migrated datasets for their individual observatories (CUAHSI will later change statuses from private to public as a batch).
- CZO Data Managers - request a DOI to be coined for each finalized dataset they wish to have designated as published.

#### Data Migration

- CZO Data Managers - Review data files in Hydroshare for completeness and accuracy of inclusion.
- Take additional steps to upload files over 500 MB. The URLs for these files were excluded from the initial migration to speed the many hour-long migration process.
- Test the migration of IML CZO data files and fix any errors.

#### Modify HydroShare to meet CZO's needs for administration and search/browse.

- Test and provide feedback to CUAHSI about the Hydroshare communities and community manager features.
- Work with CUAHSI to design a public facing discovery page for CZO, including better filtering mechanisms unique to CZO.
- Test and provide feedback on a set of iterative modifications of the CZO discovery page.

#### Modify HydroShare's editing interface to meet CZO's needs.

This component is the largest outstanding item and much work remains. Many tasks will be generated after the detailed assessment is complete. Those tasks include:

- Work with CUAHSI to create detailed plans for designing and building the editing/authoring tools. If authoring tools cannot be built by CUAHSI within existing budget, Clowder is available to address this.
- Give feedback on editing/authoring usability during an iterative testing phase.

#### Post-Migration - Train data managers, miscellaneous cleanup, and end-of project workshop

- Train all data managers on using HydroShare (CZO & CUAHSI).
- Ensure final changes to CriticalZone.org datasets have also been included in HydroShare.
- Remove dataset listings from CriticalZone.org (reduce confusion and maintenance).
- Add clear connections from CriticalZone.org to HydroShare data.
- Conduct end of project workshop (joint CZO-CUAHSI)

## Products

### Books

#### Book Chapters

Dere, A., Engelmann, C., White, T., Wymore, A., Hoffman, A., Washburne, J., and Conklin, M. (2018). Implementing and Assessing InTeGrate Critical Zone Science Materials in an Undergraduate Geoscience Program. *Interdisciplinary Teaching About Earth and the Environment for a Sustainable Future* Gosselin, D. C., Egger A.E., Taber J.J., Springer Nature. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/978-3-030-03273-9.

### Inventions

#### Journals or Juried Conference Papers

A. Perez-Fodich, L.A. Derry (2019). Modeling Ge/Si weathering signatures using thermodynamic data for synthetic Germanium minerals. *Goldschmidt Abstracts*. . Status = ACCEPTED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Aguirre A, Derry L & Kurtz A (2018). Ge/Si as a Tracer for Si in Paired Catchments of the Luquillo CZO.. *Goldschmidt Abstracts*. 24. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

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*. 96 24. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: doi.org/10.1016/j.apgeochem.2018.06.002

Baatz, R., Sullivan, P., Li Li, Weintraub, S., Loescher, H., Mirtl, M., Groffman, P., Wall, D., Young, M., White, T., Wen, H., Zacharias, S., Kühn, I., Tang, J. Gaillardet, J., Braud, I., Flores, A., Kumar, P., Lin, H., Ghezzehei, T., Gholz, H., Vereecken, H., and Van Looy, K. (2018). Integration of terrestrial observational networks: opportunity for advancing Earth system dynamics modeling.. *Earth Surface Dynamics*. 9 593. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Brantley, S., White, T., West, N., Williams, J., Forsythe, B., Shapich, D., Kaye, J., Lin, H., Shi, Y., Kaye, M., Herndon, E., Davis, K., He, Y., Eissenstat, D., Weitzman, J., DiBiase, R., Li, L., Reed, W., Brubaker, K., and Gu, X. (2018). Susquehanna Shale Hills Critical Zone Observatory: Shale Hills in the context of Shaver's Creek watershed.. *Vadose Zone Journal*. 17 180092. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.2136/vzj2018.04.0092

Derry LA, Horowitz F (2018). Tree-driven redistribution of mineral nutrients in a temperate forested shale catchment.. *AGU Fall Meeting*. B211-2439. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Derry, LA (2018). Late Cenozoic Constraints on Carbon Cycle Forcings.. *Goldschmidt Abstracts*. 558. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Derry, LA (2018). Weathering mass losses, plastic deformation and hydrologic evolution in a volcanic landscape. (Invited).. *AGU Fall Meeting*. H53H-1695. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Grant K, Galy V, Derry LA, Hemingway JD, Chadwick OA (2019). Mineral control of stabilization of soil organic carbon in a basaltic soil.. *Biogeochemistry*. . Status = UNDER\_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Grant K, Galy V, Haghypour N, Eglinton T & Derry L (2018). Multi-Level Radiocarbon Analysis of Hawaiian SOC.. *Goldschmidt Abstracts*. 2151. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes

Haas, Don (2018). Imagining Possible Futures of Geoscience Educational Media. *Association of Earth Science Editors 52nd Annual Meeting*. 52 <http://www.aese.org>. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; OTHER: <http://www.aese.org/shell.html?page=AESE2018&menu=l>.

Haas, Don (2018). Thoughts On Why The Earth Science Literacy Principles Have Not Conspicuously Changed (And Probably Will Not Conspicuously Change) Educational Outcomes: New User-manuals Do Not Yield New Systems.. *Geological Society of America abstr. progs.*. . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; OTHER: <https://gsa.confex.com/gsa/2018AM/webprogram/Paper321699.html>

Hemingway JD, Rothman DH, Grant KE, Rosengard, SE, Eglinton TI, Derry LA, Galy VV (2019). Aging and preservation of natural organic carbon. *Nature*. . Status = AWAITING\_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Inagaki TM, Possinger AR, Grant KE, Mueller CW, Derry LA, Lehmann J, Kögel-Knabner I., (2019). Subsoil carbon stabilization along a climate gradient.. *Geochim. Cosmochim. Acta*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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King E.K., Hodges C.A., Chapela Lara M., Aguirre A.A., Foster M.A., McClintock M.M., Richardson J.B. (2019). 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

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- Marcais J, Harman C, Derry L (2019). Unraveling the critical zone storage structure through in streams tracers sampling: insights from numerical experiments.. *Geophysical Research Abstracts*. 21 EGU2019-13717-2. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes
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- Perez-Fodich A & Derry L (2018). Tracking Fe-Oxidation in Spheroidal Weathering of Basalts.. *Goldschmidt Abstracts*. 2151. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes
- Richardson J, Kumpf B & Derry L (2018). Examining the Role of Organic Compounds and Secondary Minerals on Ga/Al Fractionation in the Critical Zone.. *Goldschmidt Abstracts*. 2151. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes
- Richter, D., Billings, S., Groffman, P., Kelly, G., Lohse, K., McDowell, W., White, T., et al. (2018). Ideas and perspectives: Strengthening the biogeosciences in environmental research networks.. *Biogeosciences*. 15 4815. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Soper F, Chamberlain S, Derry L, Sparks (2018). Tree-driven redistribution of mineral nutrients in a temperate forested shale catchment. *AGU Fall Meeting*. B211-2439. Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes
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- White, T., Dere, A., and Sharkey, S. (2018). Rates of sediment flux from tree throw in the Shale Hills CZO and associated satellite sites, Appalachian Mountains.. *GSA Abs. with Pro*. 50 (2), . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1130/abs/2018NE-311038
- White, T., Dere, A., and Sharkey, S. (2018). Rates of sediment flux from tree throw in the Shale Hills CZO and associated satellite sites, Appalachian Mountains.. *EOS Trans. Am. Geophys. Union*. . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes
- Yu, X., Lamacova, A., Shu, L., Duffy, C., Kram, P., Hruska, J., and White, T. (2019). Data rescue in manuscripts: a hydrologic modeling study example.. *Hydrological Sciences Journal*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

## Licenses

### Other Conference Presentations / Papers

- Sharkey, Sarah (2018). *Critical Zone Observatories: Studying where rock meets life*.. CUAHSI Biennial Meeting. Shepherdstown, WV. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Haas, Don (2018). *Rewriting the User Manual Ain't Enough: Why Education Reforms Fail to Improve Outcomes and What We Might Do to Change That (Keynote Address)*.. National Association of Geoscience Teachers Eastern Section Annual Conference.. Millersville, PA. Status = PUBLISHED; Acknowledgement of Federal Support = No
- Haas, D., White, T., and White, L. (2018). *Selected technical tools approach to fieldwork*.. Earth Educators Rendezvous. Lawrence KS. Status = PUBLISHED; Acknowledgement of Federal Support = No

Haas, Don (2018). *Why Haven't Educational Reforms Improved Outcomes on a Broad Scale? What Can We Do To Change That? (Keynote Address)*. New York State STEM Education Collaborative. Alfred, NY. Status = PUBLISHED; Acknowledgement of Federal Support = No

## Other Products

### Other Publications

Sanderson, Katherine (2018). *With 'Make Our Planet Great Again,' France aims to lead world in climate research*. Chemical & Engineering News, Volume 96 Issue 5 | pp. 24-25 article about Derry and other MOPGA laureates. 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	1
White, Timothy	Co PD/PI	2
Richardson, Justin	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Duggan-Haas, Don	Other Professional	2
Lubinski, David	Other Professional	3
Ross, Robert	Other Professional	1
Moore, Alexandra	Staff Scientist (doctoral level)	0
Camacho-Colon, Christian	Non-Student Research Assistant	3
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: 1

Contribution to the Project: PI, managed subcontracts, wrote reports, led data management effort

Funding Support: NSF

**International Collaboration:** Yes, France

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

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**Timothy S White**

**Email:** tswite@essc.psu.edu

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

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Director of National Office, led all meeting activities, launched International CZ Summer School, opened Belmont Forum effort

**Funding Support:** NSF

**International Collaboration:** Yes, Italy

**International Travel:** Yes, Italy - 0 years, 1 months, 0 days

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**Justin Richardson**

**Email:** justin.richardson@cornell.edu

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

**Nearest Person Month Worked:** 1

**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

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**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

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**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. 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

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**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

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**Alexandra Moore**

**Email:** afm113@gmail.com

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

**Nearest Person Month Worked:** 0

**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

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**Christian Camacho-Colon**

**Email:** ccc266@cornell.edu

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

**Nearest Person Month Worked:** 3

**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:** 3 months CZO-NO NSF award (2018)

**International Collaboration:** No

**International Travel:** No

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**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. Played significant role in organizing logistics for All Hands workshop in June 2017.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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

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<b>Name</b>	<b>Type of Partner Organization</b>	<b>Location</b>
CUAHSI	Other Nonprofits	Melrose, MA
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 California	Academic Institution	Berkeley
University of Colorado	Academic Institution	Boulder, CO
University of New Hampshire	Academic Institution	Durham NH

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

**CUAHSI**

**Organization Type:** Other Nonprofits

**Organization Location:** Melrose, MA

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

In-Kind Support

Facilities

Collaborative Research

**More Detail on Partner and Contribution:** CUAHSI is a major partner on the data management effort.

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**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 concentration 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.

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**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:**

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## **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).

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## **University of California**

**Organization Type:** Academic Institution

**Organization Location:** Berkeley

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

Collaborative Research

**More Detail on Partner and Contribution:** Collin Bode contributed to data management effort as a programmer and data specialist

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## **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:**

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## **University of New Hampshire**

**Organization Type:** Academic Institution

**Organization Location:** Durham NH

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

Collaborative Research

**More Detail on Partner and Contribution:** Miguel Leon has been a contributor to the data management effort. He moved mid year from University of Pennsylvania to the University of New Hampshire, but continued his role

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

Nothing to report

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## **Impacts**

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

The CZO National Office continues to play a key role in maintaining a high and intense level of communication across the Critical Zone science community. The activities, from regular but essential meetings of the CZOs and CZ leaders,

newsletters and updates, the new CZ Summer School, and a strong meeting presence knit together not only the CZOs in the US, but the broader CZ science community. The NO also is deeply engaged in international cooperation, and in communication and cooperation with other US based science programs such as LTER. Our visibility and importance to the community have quite clearly grown with time.

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

Impacts in science education include new resources and approaches that satisfy *The Next Generation Science Standards (NGSS)* [1]. The highly interdisciplinary nature of the CZ, the scientists' systems approach to understanding the nature, structure, and function of the CZ, and the fact that CZ can be found outside every schoolhouse door make it exceptionally well-suited to meeting the expectations of the NGSS. CZ Science is also "three-dimensional" in the NGSS sense. The resources in the expanded Educational Resources Collection (<http://criticalzone.org/national/education-outreach/resources/>) collectively fit this description, and some resources within the collection do so standing alone.

The Resources Collection has both nearly doubled in size and seen improvements to the user-interface over the last several months. The collection now boasts more than 40 resources appropriate to educators in a wide variety of settings, and for use by the general public as well.

Improvements to the interface make it simple to preview each resource. Clicking the preview button reveals a brief description with a descriptive image, the educational objectives and grade levels or audience the resource target, what observatory produced the resource, its authors, and, the funding source for its creation. Searches may be filtered to target videos or Virtual Fieldwork Experiences (VFEs), and by audience.

Included within the collection are activities or resources ranging in scale from a single lesson to curriculum materials designed to span an entire course. There are several short videos and video collections, VFEs and resources for making VFEs, a smartphone app, laboratory activities, articles that describe specific teaching activities and more generally how CZ Science is very well suited to meeting the needs of the NGSS.

The behind the scenes interface for resource creators has also been simplified, making it easier for CZ staff to enter resources into the collection. This means that updates to the collection should happen frequently.

We have also introduced the idea that CZ Science might go beyond providing content for science teaching, but also provide a model for the restructuring of the system of science education. Science education reforms of the last several decades have failed to improve outcomes of the system of science education in any conspicuous way. That is, there is no obviously discernable indicators that the American populous is more scientifically capable today than they were forty years ago that can be traced to innovations in science education.

Sweeping innovations in other societal systems often share certain characteristics that are rare in educational reform efforts. CZ Science shares several of these characteristics of successful innovations. Such innovations are "optimally distinct," [2] bringing together two or more well understood ideas in novel ways and being different enough from current practice to make a difference, but not so different as to be difficult to understand or implement. Successful innovations are often also characterized by the replacement – not merely refinement – of components of the infrastructure and/or technologies fundamental to these systems. At this point, the impact of these ideas is minimal – a few thousand scientists and educators have been exposed to the ideas through presentations and publications – but the potential impact is great. A manuscript is in preparation.

### **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?**

The development of the Hydroshare database for CZO data and metadata will have a major impact on the accessibility, longevity, and use of CZO data. We will have more to report on that in the next reporting period, as we will have a better

idea of usage statistics. But this represents a major step for the CZO community, long overdue.

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

Nothing to report.

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

The recent growth of a sociology of science and environmental literature that uses the concept of the Critical Zone is a clear sign that this concept, and our efforts to disseminate it, are having impacts beyond the traditional science and engineering disciplines. CZO NO personnel are participating in these activities in the 2018-20 period, and we will have more to report in 2020, both on work involving CZO NO personnel and the broader spread of the Critical Zone concept. But a few examples include a New York Times Magazine on Bruno Latour and the Critical Zone, with photos including Louis Derry and Jerome Gaillardet, and new articles by Latour and Gaillardet and by Derry in preparation.

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**Changes/Problems**

**Changes in approach and reason for change**

Nothing to report.

**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.