# Cyberinfrastructure Development for the Western Consortium of Idaho, Nevada, and New Mexico

## Year 3 Annual Report (2011/2012)

*Cooperative Agreements:* *EPS – 0919123 (Nevada)*
*EPS – 0919514 (Idaho)*
*EPS – 0918635 (New Mexico)*

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# A. Executive Summary

## Vision, Goals, and Objectives of Project

The **vision** of the Western Consortium for Cyberinfrastructure Development is *to transform communication, climate change science, and education in our tri-state (ID, NV, NM) region*. Moreover, a key outcome will be sustained partnerships among our jurisdictions that will enhance our competitiveness for research funding and enable us to better address 21st-century, grand scientific, and societal challenges. The overarching **goal** of the Consortium's Track 2 RII is *to promote knowledge transfer to scientists, educators, students, and citizens within and beyond the Consortium by enhancing state cyberinfrastructure (CI) and to enable the community science that is required to address regional to global scientific and societal challenges related to climate change.* To meet this goal, there are three primary **objectives**:

1) Promote communication and collaboration by increasing connectivity and bandwidth (*Connectivity Component*);
2) Promote discovery by supporting community-based climate change science through enhanced interoperability between models and other software components, providing improved access to and usability of Consortium data products by adopting standards-based data management and access models, and supporting new data assimilation, analysis, and visualization capabilities (*Interoperability Component*); and
3) Utilize CI to integrate research and education (*Cyberlearning Component*) by: focusing on graduate student, postdoctoral researcher, and faculty development; extending science education into middle and high schools; and improving outreach to business and industry.

Teams were formed to carry out the activities tied to each of the objectives above. These three components—Connectivity, Interoperability, and Cyberlearning—form the organizational structure of the project as a whole.

## Summary of Efforts and Key Accomplishments

*Intellectual Merit*

Year 3 of this project has continued and expanded on the efforts of the previous years. The key accomplishments summarized below and described more fully in the body of this report will enable researchers from many disciplines in each of the jurisdictions to more effectively share data and models and to integrate their products into other national and international systems and projects (such as DataONE, EarthCube, geo.data.gov, CUAHSI HIS, and GEOSS). Improved connectivity is facilitating and enabling data-intensive research, collaborative development, distributed experiments, grid-based data analysis, high performance networking, social networking, and cyber-enabled learning. Improvements in connectivity and enhanced interoperability and accessibility of data and models will enable the Consortium to realize its community science objective and transform the way the three states do research.

*Broader Impacts*

From its inception, the proposed CI investments in the Consortium were designed to achieve broad impact and to add value by leveraging existing resources and infrastructure within the institutions, jurisdictions, and regions. The Consortium has further developed its commitment to increasing the diversity of the STEM workforce through the development of a Tri-State Diversity Plan, which is being implemented in all three states. The Consortium's investment in improved connectivity benefits rural institutions and those that serve Hispanic and Native American students and faculty. The project is making high-quality environmental data, information, and models available for STEM education and outreach, including classroom and laboratory use and student research. The Consortium's Cyberlearning activities will have long-lasting effects by training the next generation of scientists and targeting a range of geographic and cultural populations. Furthermore, we are preparing the future scientific workforce with better-developed quantitative reasoning, data analysis, and modeling skills. Cyberlearning activities support educational activities at all educational levels, including the development and dissemination of educational materials for middle school and high school students with large numbers of Hispanic and Native American students.

*Efforts and Key Accomplishments*

The Western Tri-State Consortium has organized project activities into three components, based on its three primary objectives: 1) Connectivity, 2) Data and Model Interoperability, and 3) Cyberlearning. A summary of the project's efforts and key accomplishments are presented below as they align with these three components.

***Connectivity***

- Improved connectivity to two major research stations, at Hagerman and Kimberly, Idaho, is fully operational and expanding opportunities for research.
- Upgraded networking connectivity in Nevada (at the north end) to 10GBps continues to better serve the state's institutions during Year 3.
- Networking and video connectivity within Nevada are in use.
- 27 of the education portals (Gateways) have been installed at various campuses across New Mexico, and usage and training for use continues.

***Data and Model Interoperability***

- Continued development of each state's data portal with shared interoperability standards; data portals in all three states are operational (though the ID portal is currently in transition to a new platform).
- The implemented data portals support the wide variety of identified interoperability standards, with all three portals and underlying systems supporting selected ISO 19115-2 metadata standard, and NM and ID currently supporting the OGC WMS, WFS, and WCS data visualization and access standards.
- Defined a specific ISO 19115-2 metadata content model (in consultation with NOAA metadata experts), that has undergone initial testing in all three states and is expected to be operational for metadata and data replication by the end of the project year.

- Collaborated with numerous CI programs and networks for exchange of technical information and data and metadata.
- Continued development of the Demeter and Persephone frameworks to enable web services for data exchange and model execution.
- Initiated the visual coupling framework for integrating the WRF model with a subset of surface models.

***Cyberlearning***

- Provided information and funding for CI-related training for graduate students and faculty.
- Hosted a Cyberlearning (CL) Summit for dissemination and sustainability.
- McCall Outdoor Science School, a collaborating organization, developed a Cyberlearning website and continues to enhance site content and HIS database interface.
- Developed a pilot program to adapt and integrate Cyberlearning components developed in Nevada into STEM classes in Idaho.
- Funded five new Supercomputing Challenge teams and three new teams in Project GUTS (Growing Up Thinking Scientifically) in New Mexico.
- Teachers in New Mexico Tech's Masters of Science Teaching Program developed middle school and high school curricula related to climate science
- FastForward NM, a collaborating organization provided computer and internet training to small business entrepreneurs in rural NM communities.

*Cross-Component Accomplishments*

Efforts that focus on *diversity, outreach and communication, evaluation and assessment,* and *sustainability* cross each of the components and are coordinated by project leadership. Year 3 efforts and key accomplishments in these areas include:

- Continued implementation of a Tri-State Diversity Strategic Plan that identifies six strategies for broadening the participation of underrepresented minorities (URM) and women in STEM. Action items were reviewed during the Diversity Working Group at the 2012 Tri-State Meeting in April.
- Maintained and utilized a Consortium website (www.westernconsortium.org), as well as a Tri-State Meeting website with both presentation and research poster content available to the public.
- Held the Western Tri-State Consortium Annual meeting in Idaho for nearly 200 participants; agenda included workshops, keynote speakers, a student poster competition and 12 research and education sessions.
- Underwent a review by the External Advisory Committee (EAC) and responded to the EAC Report.
- Funded two Tri-State Innovation Working Groups.
- Hosted a second meeting of representatives of the governing councils from the three states to discuss opportunities for continuing collaborations beyond this award.

*Management Structure*
The project *management structure* is designed to encourage interaction among the three states and the various components; a representation of the structure is on page 42. The State Directors, PI, Co-PIs, Project Administrators, and Education, Outreach, and Diversity Coordinators form a Management Team. Each Component Team has an overall component lead supported by state leads and team members from each of the three states. An External Evaluator and an External Advisory Committee provide evaluation and assessment to the project Management Team. Each component team has monthly meetings to coordinate activities and chart progress towards objectives. Finally, to encourage effective project management, the PI, Co-PIs and Component Leads hold monthly Leadership meetings. Most meetings have utilized our cyberinfrastructure via video, Webex, or GotoMeeting.

*Response to External Advisory Board Report*
The Consortium's Track 2 project has a seven-member External Advisory Committee (EAC) consisting of internationally and nationally recognized experts in the project's focus areas. The EAC met with the project's leadership and team members on February 23, 2012 in Santa Fe, NM. Based on presentations made by the project team, the EAC reviewed progress toward achieving outcomes of the project, made constructive suggestions for improving and/or changing the direction of the work underway, and provided suggestions for collaborations within and outside the Tri-State region, as well as suggestions for funding opportunities appropriate to our project focus. The EAC summarized their comments and recommendations in a report to the Consortium. The project team responded to each recommendation with strategies on how we will incorporate the recommendations into the project (see Appendix B).

*Response to Quarterly Evaluation Reports*
After completion of the Year One Evaluation Report, Dr. Shaw withdrew from the project. The project's new external evaluator, Dr. Lisa Kohne, of SmartStart Educational Consulting Services, submits quarterly Evaluation Reports to the project leadership. These have also been provided to the cognizant Program Director. Component leads and the Management Team review the recommendations in the report and make appropriate adjustments to some program activities to best support the long-term project goals, objectives, and desired outcomes.

# B. Detailed Report

## 1. RII participants and participating institutions

See Fastlane entries for Idaho, Nevada, and New Mexico collaborative awards. In year three, the number of participants in the Track 2 Tri-State Consortium including faculty, staff, and students, totaled 88, an increase of 30 from Year 2. Of the total, 33% were from Idaho, 24% were from Nevada, and 43% were from New Mexico. The percentage of women, underrepresented minorities (URM), and persons with disabilities in the Consortium was 39%, 14%, and 1%, respectively.

Demographics of Western Tri-State Consortium Participants, Year 3

| **Institution** | **Male** | | **Female** | | **Totals** | **URM** | | **Disability** | |
|---|---|---|---|---|---|---|---|---|---|
| Idaho | | | | | | | | | |
| University of Idaho | 16 | | 5 | | 21 | 2 | | | |
| Idaho State University | 3 | | 1 | | 4 | | | | |
| Boise State University | 2 | | | | 2 | | | | |
| USDA | 1 | | | | 1 | | | | |
| CRITFIC | 1 | | | | 1 | | | | |
| Total | 23 | 79% | 6 | 21% | 29 | 2 | 7% | | |
| Nevada | | | | | | | | | |
| DRI | 2 | | 1 | | 3 | | | | |
| UNR | 8 | | 2 | | 10 | | | | |
| UNLV | 1 | | 1 | | 2 | | | | |
| NSHE | | | 5 | | 5 | 2 | | | |
| Clark County School District | | | 1 | | 1 | | | | |
| Total | 11 | 52% | 10 | 48% | 21 | 2 | 10% | | |
| New Mexico | | | | | | | | | |
| UNM | 8 | | 7 | | 15 | 2 | | 1 | |
| NMT | 10 | | 7 | | 17 | 5 | | | |
| NMCAC | | | 1 | | 1 | | | | |
| Los Alamos National Laboratory | 1 | | | | 1 | | | | |
| Supercomputing Challenge | | | 3 | | 3 | | | | |
| GUTS | 1 | | | | 1 | 1 | | | |
| Total | 20 | 53% | 18 | 47% | 38 | 8 | 21% | 1 | 3% |
| **All Three States** | **54** | **61%** | **34** | **39%** | **88** | **12** | **14%** | **1** | **1%** |

## 2. Program/Project Description

### Research Accomplishments and Plans

Specific research accomplishments and plans are provided below for the project's three primary components: (1) Connectivity; (2) Data and Model Interoperability; and (3) Cyberlearning.

### Connectivity

In Year 3 the Connectivity Component has focused on finishing the upgrades prescribed in the proposal so that they can be used by the others involved in Track 2 activities as well as by Track I researchers and others.

*Idaho*

In Idaho, the primary connectivity upgrades are finished. In Year 3, connectivity upgrades to two major University of Idaho (UI) research stations were operational. The increase in bandwidth has made a significant positive improvement at these sites (see Highlights included with this report). Networks also were upgraded to key researchers and their labs at Idaho State University (ISU). ISU has been able to expand the scope of the 1Gbps Inter-building backbone upgrade from the original four buildings to 16 buildings. In addition, ISU was able to leverage EPSCoR RII C2 funding to connect to the Idaho Regional Optical Network (IRON) for high-speed access to commodity internet in Year 3, which adds value to both projects. Combined, these improvements have moved ISU from a congested Internet environment toward an environment with overhead that is responsive to large file transfers needed by the research community. Also in Year 3, Boise Center Aerospace Laboratory (BCAL) was upgraded from 10/100Mbps to the desktop to 1Gbps to the desktop in research offices and labs. BCAL is led by Dr. Nancy Glenn, and plays a key role in Idaho's Track 1 RII activities also. These upgrades have allowed congested links to now function without dropped packets improving transfer speeds significantly.

*Nevada*

In Nevada, the connectivity upgrades are finished. Networking connectivity into the state (in northern Nevada, as described in the proposal) has been upgraded to 10Gbps and networking and video connectivity upgrades within the state has been installed and are in use.

*New Mexico*

In New Mexico, 27 education "Gateways" have been installed at various campuses across the state. New Mexico leveraged its C2 award to develop course materials that use the Gateways at community colleges and to provide additional training for faculty in using the Gateway technology. (8 installed - January 2010, 13 installed - May 2010, 6 installed - June 2011).

## Data and Model Interoperability Component

In Year 3, the efforts of the Data and Model Interoperability component became increasingly integrated across all three states, with coordination provided by the CI Working Group that was established through the Consortium's RII (Track 1) projects with representation from all three states. Coordinated model and data interoperability activities for the Tri-State Consortium continued to focus on two primary sets of activities:

- Interoperable data portal implementation, and
- Model components and interoperability framework specification and development.

In addition, work has focused on laying the groundwork for integrating the consortium's capabilities with other national and international programs and networks. These integration efforts have concentrated on the development of capabilities directly aligned with the CUAHSI HIS system and with other national networks (i.e., DataONE, geo.data.gov, CUAHSI HIS, and GEOSS) that implement the interoperability standards supported by the Tri-State Consortium.

### *Interoperable Data Portals*

During Year 3 of the EPSCoR Track 2 project, significant progress has been made in the development of the individual data portals within each state, all of which share a common constellation of interoperability data standards that have been identified as target standards for all three states (Figure 1). Idaho's portal is in transition to a new platform.

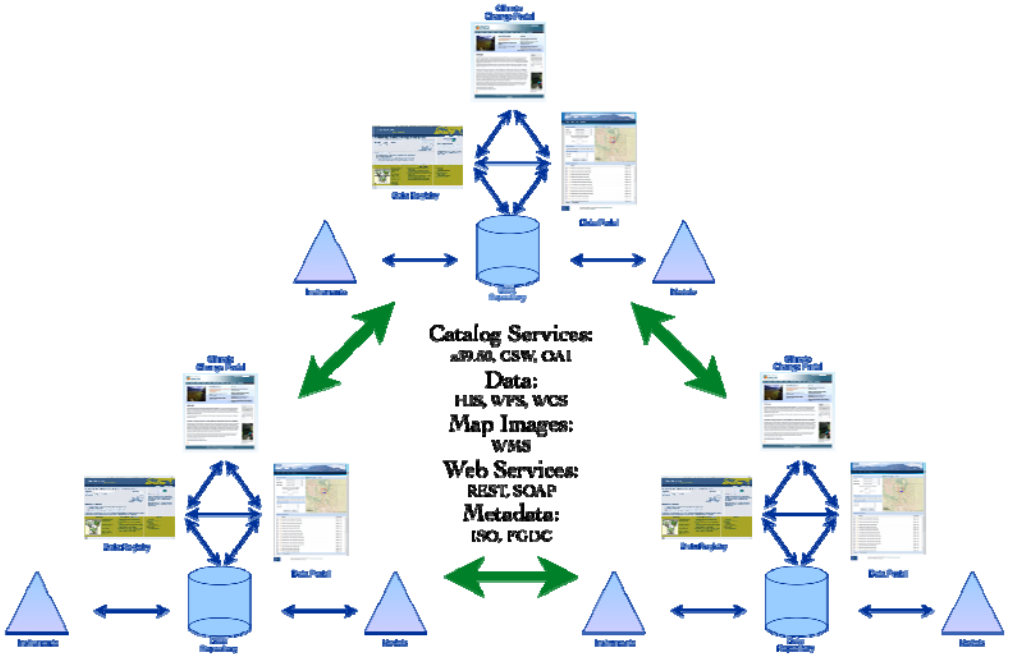


Figure 1. Conceptual diagram representing the standards-based connectivity between the Tri-state data portals

In an effort to maximize the impact of EPSCoR data and CI investments both within and beyond the EPSCoR project, a wide range of open interoperability standards have been identified (as a cooperative activity within the Tri-State CI working group) as target standards for CI development. These standards related to three broad areas of interoperability: data access and visualization, metadata and catalog services, and connectivity with other national networks and programs. The specific target standards that have been identified include:

- Open Geospatial Consortium (OGC) Web Map Service (WMS) – data visualization through the delivery of map images
- OGC Web Feature Services (WFS) – data delivery focused on vector data (points, lines, polygons) and their associated attributes. Point observational data are included in this particular data model.
- OGC Web Coverage Services – data delivery for gridded data such as elevation models, flow surfaces, remote sensing data, and model outputs
- ISO 19115, 19115-2, 19139 – international geospatial metadata standard
- Federal Geographic Data Committee CSDGM – US Federal geospatial metadata standard
- OGC Catalog Services (CAT/CSW) – catalog services standard
- Z39.50 – catalog services standard
- CUAHSI HIS – a standard data model, metadata content model, and set of service requests developed by the hydrologic community for the discovery and exchange of point-observation data
- Representational State Transfer (REST) web services model – general purpose web service model based upon the hypertext transfer protocol (HTTP, from the IETF)

The above data and service standards have been implemented in New Mexico and Idaho. NV anticipates that WMS, WFS, and WCS will be completed by the end of project Year 3. All three states have implemented some level of support for the ISO 19115-2 metadata standard, with the focus on the component-based data-collection structural model defined during the Tri-State CI ISO metadata training held at the University of New Mexico, and during a team working group meeting held in conjunction with the 2012 National EPSCoR meeting in Coeur d'Alene, ID.

In addition to facilitating data exchange between the Tri-State EPSCoR collaborating states, the implementation of the above standards, specifications, and protocols is informed by and will enhance the ability of Tri-State EPSCoR collaborators to integrate their products into other national and international systems and projects such as DataONE, geo.data.gov, CUAHSI HIS, and GEOSS. The US Federal Government's shutdown of the Geospatial OneStop (GOS) national clearinghouse in favor of the integration of geospatial data into the ongoing data.gov initiative is an excellent example of the benefits of the standards-based approach adopted by the Tri-State CI working group. Specifically, the same metadata standards and service interfaces (FGDC and ISO, CSW and z39.50) that had previously been supported by GOS have been implemented within the new geo.data.gov system, providing a relatively seamless transition from one platform to the other for the metadata services published by New Mexico into GOS and now geo.data.gov. While the elimination of support for the NBII

network necessitated a rethinking of integration with that network, support for data discovery and delivery through CUAHSI HIS continues in both ID and NM, with NV planning to implement support by the end of the current project year.

The portal implementations in each are state-specific to that state, with the portals in New Mexico and Idaho leveraging ongoing state geospatial clearinghouse programs (Inside Idaho[1], but moving towards a more integrative data portal hosted by the Northwest Knowledge Network, NKN[2], and the New Mexico Resource Geographic Information System[3]). Nevada's portal has been developed from the ground up as a tightly integrated climate change portal within which both data and other information are available.

The operational data portals for each state can be found at the following web addresses:

- **Nevada**: http://sensor.nevada.edu/NCCP/Default.aspx
- **New Mexico**: http://nmepscor.org/dataportal
- **Idaho**: http://insideidaho.org/webapps/search/epscor_browse.aspx

The further development of NKN in Idaho is a significant accomplishment during the performance period. In keeping with the Track 2 vision of creating a Data Management facility, the award provided Data Manager and CI Coordinator positions, thus initiating this large-scale regional data management project. NKN is expected to provide comprehensive data life cycle management for researchers throughout the Pacific Northwest region. Following Idaho EPSCoR's initial purchase of development and production server equipment to support the NKN, the University of Idaho Office of Research and Economic Development (ORED) signed a $325K, three-year lease for a set of servers, networking equipment, and storage hardware. The Department of Energy's (DOE) Idaho National Laboratory (INL) matched the University's purchase and acquired an identical set of equipment to be housed in their datacenter in Idaho Falls. Altogether, this investment in data management infrastructure added up to $650K and resulted in the deployment of 500 terabytes of high performance, geographically distributed data storage infrastructure in Idaho. This server and storage equipment was completely deployed by March of 2012. NKN is envisioned to be a long-term resource to facilitate CI collaboration within the Tri-State Consortium.

An additional component of the interoperable Tri-state portal development activity is the implementation of a metadata replication and targeted data replication model between the three states. In consultation with external experts from USGS, NOAA, DataONE, and the Oak Ridge National Laboratory, the Tri-state CI working group has developed a model for data synchronization that is mediated through use of ISO 19115-2 metadata, with the involved metadata being hosted through a set of web accessible folders that are maintained by each state. The overall conceptual model is illustrated in Figure 2.

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[1] http://insideidaho.org/

[2] http://northwestknowledge.net

[3] http://rgis.unm.edu

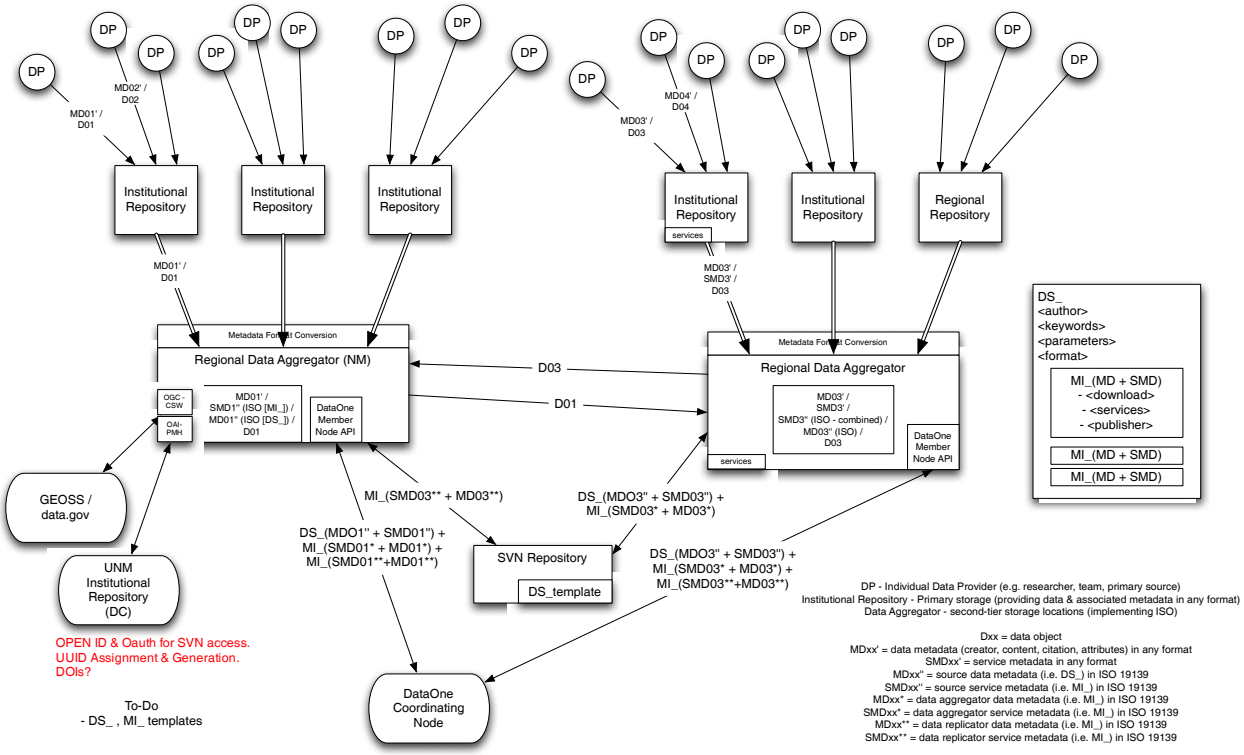



**Figure 2. Metadata Component Replication Diagram, representing flow of metadata content from data providers through institutional repositories and into the regional data aggregators representing the Tri-State EPSCoR Data Portals.**

The development of the Tri-State data portal capabilities has also been informed by interaction with external projects and programs, either in the form of technical exchange, or through design for integration through implemented standards.

*Data and Metadata Exchange and Technical Information Exchange*

Areas of interaction with other CI activities outside the Tri-state consortium include both integration in the areas of data and metadata exchange and technical interactions. Following are some examples of these areas of interaction:

- The development team (providing the lead in the CI development efforts for the RII) at the Earth Data Analysis Center (EDAC) and Idaho's INSIDE Idaho has contributed metadata to the NBII network. EDAC has developed and hosted a number of clearinghouse nodes within the Federal Geospatial Data Committee's (FGDC) network and provided some of the earliest web accessible metadata records into the Geospatial OneStop.
- New Mexico and Idaho have established HIS instances for the capture and documentation of point time-series data into the HIS service model. These HIS services provide for publication and discovery through the CUAHSI network.
- New Mexico has completed the initial ingest of historic SNOTEL and SCAN data from the NRCS servers (representing over 470 million individual observations), providing data download of individual station data via web interfaces. These data will

periodically be harvested into the New Mexico EPSCoR data portal, through which they are republished using the enhanced services available through the portal.

- New Mexico's EDAC was one of the early recipients of funding from the FGDC CAP program for the development and delivery of metadata training and has continued to provide training for over 15 years.
- Karl Benedict (Director of EDAC, and CI lead for NM'S RII-3 Track 1 project and for the Tri-State Track-2 project) serves as EDAC's representative to the Open Geospatial Consortium, and the Federation of Earth Science Information Partners (ESIP Federation), for which he currently serves as President, and has previously served as chair of their Information Technology and Interoperability Committee.
- Idaho's Greg Gollberg and Luke Sheneman, and New Mexico's Karl Benedict serve as members of the DataONE Data User's Group (DUG).
- Members of the Tri-State CI Team participated in a three-day ISO metadata training session hosted at the LTER Network Office (also providing participants in the training) and provided by ISO metadata experts from NOAA.
- Through face-to-face meetings at the bi-annual meetings of the ESIP Federation and the second meeting of the DataONE DUG, Karl Benedict has had extended discussions with the developers of NEON's CI, both about their planned development and deployment efforts, and about service models that would facilitate the integration of NEON data products and services into broader networks of users.
- Exchanges between CSDMS personnel and Jigar Patel (developer of the Visual Model Coupler [see below] have indicated an interest in integration of the VMC into the CSDMS system.

Following last project year's researcher outreach activities associated with the IWG, a dialog between researchers and CI developers from the Tri-States was continued at the annual Tri-State Meeting in Sun Valley, ID, in which an additional 90-minute workshop and usability test was held with researchers, students, and educators attending the meeting.

***Model Components and Interoperability Development***

Model component and interoperability development activities have focused on three areas:

- Development of new model components for integration into climate modeling systems;
- Development of a web-services enabled interoperability framework for data processing in support of model execution; and
- Development of a visual model coupler (VMC) for linking the WRF model with surface modeling systems.

*Developing Model Components*

Model component development efforts are focused around modeling the interactions between landscape and climate across spatial and temporal scales. Modeling work by the team at the University of New Mexico has continued in the third project year, with two parallel development efforts being undertaken. First, experimental integration of averaged precipitation data generated by the WRF model is being used to drive a longer time step land surface simulation model. The second modeling effort focuses on the development of

meteorological and climate downscaling models that integrate topographic effects into precipitation estimates developed from these models.

Model code development for the integrated models will continue to be incorporated into the Community Surface Dynamics Modeling System (CSDMS; http://csdms.colorado.edu). The CSDMS facilities allow for archiving of progressive versions during code development along with examples of input and output. Archived code is publically and freely available, and can be integrated with a multitude of other models that are also part of the CSDMS.

*Web-services Enabled Interoperability Framework*

The development of the Demeter framework and associated Persephone web interface by Eric Fritzinger (University of Nevada Reno) has been substantially shaped by interaction with collaborators in Idaho (Dan Ames) and New Mexico (Karl Benedict), as well as through last year's IWG workshops. The framework makes use of web services for data exchange and model execution. It is based upon the workflow metaphor and includes a graphical user interface using the Silverlight framework and a Python scripting language environment. The development sequence for the framework has evolved based on feedback from Tri-state researchers and EPSCoR External Advisory Committee members and currently consists of:

- Visual programming environment interconnecting models (since October 2009)
- Focus on making use of web services (since April 2010)
- Specific focus on data consolidation, conversion, and utilization (since November 2010)
- Integration of the DotSpatial software components into the capabilities of the framework, particularly with a focus on integration of CUAHSI HIS data and services into the framework (illustrated in Figure 3)

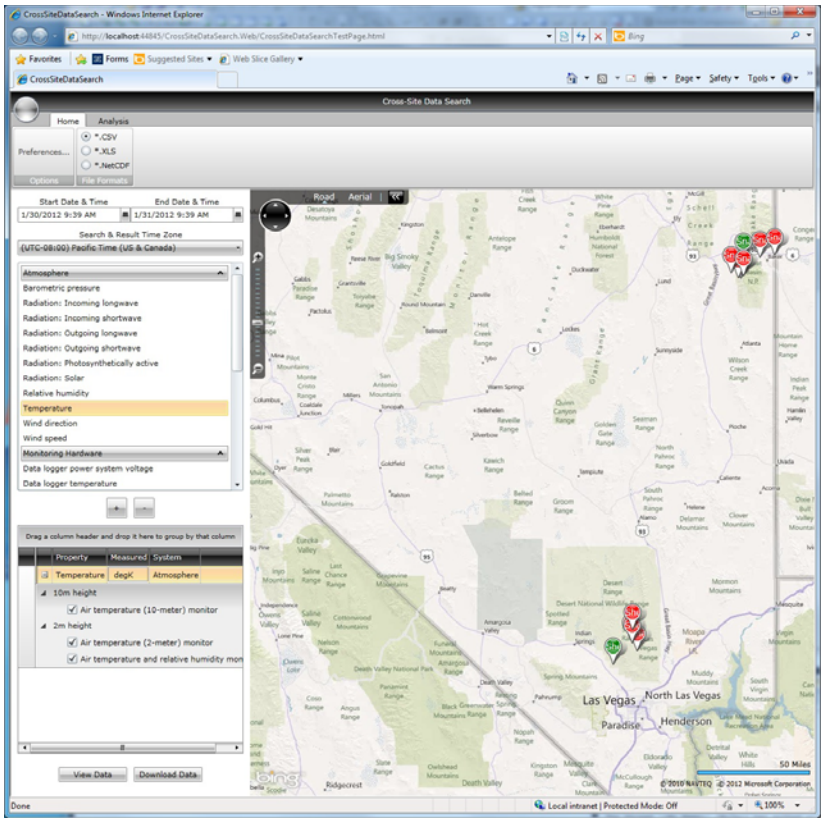



**Figure 3. Persephone web interface illustrating integration of DotSpatial software capabilities for interacting with CUAHSI HIS data services.**

Currently, the framework has the ability to read and write NetCDF files, can execute defined workflows, can access Web Feature Services, retrieve data from those services, and interact with CUAHSI HIS services. Current work is focused on:

- Completing Web Feature Services implementation through integration with other framework components
- Accessing Web Coverage and Web Processing Services
- Improving the user interface
- Improving the execution run-time
- Working on additional integrative scenarios with ID and NM

*Visual Model Coupler*

Researchers at the University of Nevada Reno have been working on the development of the visual model coupler (VMC) for the WRF model. They have focused on developing the specifications needed to develop a coupling framework for integrating the WRF model with a subset of surface models. Thus far, the VMC development effort has completed the design and initial prototype development.

With the above described work completed, current work is focused on:

- Development of a web-based prototype
- Testing of the developed prototype

- Extending the VMC with a notation and interface for visual scripting of data conversions

**Cyberlearning**

Activities in the Cyberlearning component continue to provide CI-related educational opportunities at all educational levels. Year 3 activities have completed the tasks associated with integrating research with education. Primary activities were:

- Offer and support CI training related to computation and climate change for graduate students, post-doctoral researchers, and faculty.
- Develop and disseminate educational materials for K-12 students, both in-school and extra-curricular.
- Provide training that connects small business owners with CI capabilities in New Mexico.
- Implement a pilot-program to adapt online-climate education resources to Idaho educational settings.

***CI Training***

The Cyberlearning Component team developed a listing of available CI-related trainings and continued to use the protocol they developed for graduate students, post-doctoral researchers, and faculty to apply for travel awards to attend trainings. Each state announced the CI training opportunities on their web site and used an internal process to make travel awards. After attending a workshop or conference, participants completed a survey that was designed by the External Evaluator to assess the impact of the training. Example trainings included: a group of three Track 2 participants were supported to participate in a Computational Thinking Panel at SC11; a New Mexico graduate student attended the 3rd Annual Santa Fe Conference on Global and Regional Climate Change; Idaho staff attended an ISO 19115-2/19139 Geospatial Metadata Standards workshop, and another student is attending a tutorial for the Weather Research and Forecasting (WRF) model at the National Center for Atmospheric Research (NCAR).

CI-training was also provided at the 2012 Tri-State Annual Meeting, including a half-day workshop on Hydrologic Information System (HIS) presented by Interoperability Component team member, Dan Ames. Darko Koracin, a team member of the Cyberlearning Component, also offered a one-day workshop on Climate Modeling. Registration for these opportunities was strong, although actual attendance was lower: Climate Modeling Tutorial (26), HIS (17), C4D (25), and Systems Modeling (51).

*Interdisciplinary Modeling Course*

In addition, an interdisciplinary modeling course at New Mexico State University will be held in summer 2012 with faculty from NM, NV, and ID presenting. Thirty students from the Consortium have registered to attend. The course has a theme of addressing interdisciplinary modeling of climate change impacts on water resources. Interdisciplinary teams of students in the course do modeling projects to address water-related issues. Two significant advantages of this type of interdisciplinary, interstate, and inter-institutional activity are: 1) Interaction among faculty during course development and implementation

can lead to research collaborations for the EPSCoR projects and for additional NSF and other research proposals, and 2) interdisciplinary modeling approaches will benefit the RII projects through graduate student work in the course.

### *K-12 Educational Materials*

*Nevada*
Nevada has created a project development leadership team that includes faculty, students, and representation from the Curriculum and Professional Development Division (CPDD) of the Clark County School District (CCSD). The leadership team, which is lead by Dr. PG Schrader (UNLV), meets biweekly to plan activities. In Year 3, the Nevada group has continued these activities. Their teacher professional development summer science institute is an annual offering by CPDD-CCSD. The topics in Year 3 include specific case studies of climate impacts in Nevada. Teachers are funded through CPDD and the primary activity is a fieldtrip experience to Death Valley, CA to study the historical impact of climate change on that region. In addition to the teacher professional development, efforts have focused on further refining the C4D learning materials, disseminated on Moodle. Overall, the CPDD-CCSD partnership has eight different C4D units linked to state standards and CCSD science text. In total, 400 students used the materials in Fall 2011, and 250 students used the materials in Spring 2012. Nevada also participated in the Cyberlearning Summit where the C4D content was presented and discussed (see below) and the 2012 Tri-State meeting where a half-day workshop on C4D Death Valley Workshop was held.

*Idaho*
The Consortium continues to collaborate with the McCall Outdoor Science School (MOSS) in Idaho to further develop a Cyberlearning website. MOSS developed a Cyberlearning website to get students and teachers connected to concepts that EPSCoR scientists are studying related to "water resources in a changing climate." The site includes background information about climate models, water resources, scientists working on the EPSCoR project, and an interface for uploading hydrologic data to the CUAHSI HIS database. MOSS was awarded a NSF-funded project under Cyberinfrastructure (CI: TEAM Demo: Adventure Learning through Water and MOSS, Award #1135577). Under this funding and with separate funding awarded to Dr. Dan Ames at Idaho State University, MOSS is continuing to develop a user-friendly interface for the CUAHSI HIS database. This interface will be integrated into a new web portal that K-12 students at MOSS will use to communicate their experiences and learning during residential programs at the McCall Outdoor Science School. Students will collect, analyze, and visualize water-related data and communicate their findings to a broad audience of their peers, parents, and other interested followers of the blog site. MOSS personnel also shared the HIS work at the Cyberlearning Summit (see below) and led a NSF Cyberlearning proposal (see below).

Also in Idaho, ISU assistant professor Carie Green (Education), is using Nevada's C4D materials and adapting them to Idaho. She began the project in March 2012 and to date has constructed a Moodle website on the ISU server along with a discussion forum to solicit feedback from interested educators. Her group is evaluating NV's materials and their

applicability to Idaho students in order to determine which will be included in the curriculum for Idaho. All modules will relate to the Idaho State Curriculum Standards and materials will be developed at the appropriate level for middle or high school students. Idaho will also adapt NV's 5-DIE format to the new lessons. To adapt and build the lessons, the group has spent a significant amount of time creating new materials relative to climate change research conducted by Idaho scientists. This included interviewing researchers at Idaho State University and creating modules related to hydrology, geology, quantitative reasoning, data analysis, and modeling skills. The materials will include video clips and hands-on interactive materials for the students to explore specific topics. In addition, the group is building three modules related to indigenous communities and climate. The goal in doing this is twofold. First, the aim is to integrate indigenous concerns, perspectives, and approaches to climate change. Second, through developing culturally relevant materials the aim is to broaden participation and interest of Native American students in STEM fields. The group will also solicit content for the modules by partnering with the teacher participants in the ISTEM Adventure Learning Program held at MOSS in June 2012.

*New Mexico*
Project GUTS (Growing Up Thinking Scientifically (http://www.projectguts.org/)) is a summer and after-school science, technology, engineering, and math (STEM) program for middle school students based in Santa Fe, New Mexico and serving New Mexico. Growing up thinking scientifically means learning to look at the world and ask questions, develop answers to the questions through scientific inquiry, and design solutions to their problems. Project GUTS is hosted by the Santa Fe Institute and has been funded by the National Science Foundation, the Bengier Foundation, the Los Alamos National Bank, Lockheed-Martin Foundation, the New Mexico Public Education Department Math and Science Bureau, New Mexico Experimental Program to Stimulate Competitive Research (NM-EPSCoR), the Los Alamos National Laboratory Foundation, and private donors.

In Year 3, the Consortium supported 5 new teams for GUTS: Aspen Community Magnet School, Santa Fe; DeVargas Middle School, Santa Fe; Gonzales Middle School, Santa Fe; Sarracino Middle School, Socorro; and West Las Vegas Middle School, Las Vegas. The GUTS program includes professional development for teachers (club leaders), facilitation of club meetings, field trips, Kickoff, and the Expo Award Ceremony. Diversity is documented in the table below. EPSCoR funding allowed these schools to start their Project GUTS clubs; send teachers to the SCC Summer Teachers' Institute and other professional development workshops throughout the year; have Project GUTS facilitators visit the schools throughout the year to help teachers with further professional development and students with project development, computer modeling, and programming; and fund the two 10-week units for Project GUTS, as well as two fieldtrips, two roundtables, and the necessary supplies and club materials. In addition to the students and teachers directly involved, these participants went back to their home institutions and communicated what they learned to their fellow students and teachers. Finally, the materials developed for GUTS are available online at http://129.138.6.200/~epscor/media/curricula/EPSCoRClimateImpactsUnit.zip as part of our cyber education materials. New Mexico EPSCoR has leveraged C2 and Track 1 funding to provide additional training for club leaders and to support clubs in communities near institutions supported through C2.

**Table 1. Project GUTS demographics for EPSCoR Track 2 supported clubs**

| Site | Participants | Male Not URM | Male URM | Male N/I | Female Not URM | Female URM | Female N/I |
|---|---|---|---|---|---|---|---|
| Aspen | 9 | 2 | 2 | 2 | 0 | 3 | 0 |
| DeVargas 1 | 21 | 2 | 19 | 0 | 0 | 7 | 0 |
| DeVargas 2 | 14 | 1 | 9 | 2 | 1 | 1 | 0 |
| Gonzales | 4 | 1 | 2 | 0 | 0 | 1 | 0 |
| Sarracino | 6 | 0 | 0 | 0 | 3 | 3 | 0 |
| West Las Vegas | 8 | 2 | 2 | 0 | 2 | 1 | 0 |
| Las Vegas Memorial | 14 | 0 | 10 | 0 | 0 | 4 | 0 |
| TOTALS | 76 | 8 | 44 | 4 | 6 | 20 | 0 |

*Sustainability*

GUTS clubs have been initiated in previous project years. After receiving EPSCoR startup funding in Year 1, the Artesia and Las Vegas Project GUTS clubs have continued to participate in Project GUTS for the past two years. In Artesia, the GUTS program is integrated within the regular school day. In Las Vegas, the GUTS club has evolved into a club offered at New Mexico Highlands University open to students from surrounding middle schools. The Cameo GUTS club did not continue, but activities from Project GUTS were incorporated into the regular school day by the past club leader. Of the GUTS clubs receiving EPSCoR startup funding in Year 2, the Gadsden Middle School and Lynn Middle School GUTS clubs have continued but the Eagle Ridge GUTS club has not. The club leader at Eagle Ridge Middle School has continued to attend the Project GUTS teacher professional development workshops with hopes of reinstating the club in the future but cited increases in student load, teaching demands, and new district initiatives as competing demands on her time and energy.

The Super Computing Challenge (SCC) is a year-long experience that provides CI training for teachers as well as students. As part of starting the teams, funding was used to send teachers to the Summer Teachers' Institute (STI), which provided professional development in computer modeling and project-based learning that enabled the teachers to support a challenge team in the coming year. At the start of the school year, teachers and students from the new teams attended a Kickoff during which the students receive instruction in programming, data analysis, and the chosen SCC topic for the year (in this case, climate change). At this year's Kickoff, Lorie Liebrock coordinated an enhanced group

of faculty to consult with teams. Throughout the school year, consultants visit the students and their teachers to assist with the student projects and provide coaching for teachers. Mid-way through the school year, teams present their work-in-progress to judges and receive feedback and assistance in how to complete their projects. The competition culminates in the SCC Expo, where the students present their finished work to judges and students are given prizes, scholarships, and awards for their work.

For Supercomputing Challenge, Track 2 funding supported 5 new teams: Alamogordo High, Edgewood Elementary, and Little Earth School, Santa Fe; Mesa Middle School, Las Cruces; and Rio Rancho Cyber Academy. These schools (teachers and students) participated in the Supercomputing Challenge year-long competition including the Summer Teacher Institute (teachers only) Kickoff, Outreach, Evaluations, and the Expo Award Ceremony. Diversity is documented in the table below. In addition to the students and teachers directly impacted, these participants went back to their home institutions and communicated parts of what they learned in this experience to their fellow students and teachers.

**Supercomputing Challenge Demographic Documentation**

| Participants | | Males | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Num. Part. | URM | Not URM | N/I | URM | Not URM | N/I | with Disability |
| Alamogordo High | 11 | 4 | 7 | | | | | |
| Edgewood Elementary | 20 | 3 | 2 | | 7 | 5 | | |
| Mesa Mid School Las Cruces | 12 | 5 | 6 | 1 | 0 | 0 | | |
| Little Earth School, Santa Fe | 10 | 1 | 4 | | 2 | 3 | | |
| Rio Rancho Cyber Academy | 8 | 1 | 4 | | 1 | 2 | | |
| Total: | 61 | 14 | 23 | 1 | 10 | 10 | 0 | 0 |

As can be seen from these participant demographics, these programs have had as high as 50% participation by URM students.

NM EPSCoR (Track 2) hired students to assist primarily as consultants for SCC and GUTS (from STI to Awards Expo), but also to assist with assessment, aggregation, and sorting of links relating to climate data, visualization tools and tutorials, grants, scholarships, and EPSCoR-related training opportunities. The students also assisted in the creation of a new course aimed at preparing educators to teach their own AP Computer Science program, as described below (Java). They assisted in creating supplementary materials for published curricula from NMT's MST program to prepare it for dissemination.

In NM, the Cyberlearning component is also partnering with NM Tech's Masters of Science Teaching Program, by supporting teachers to create educational materials. Of these teachers, five have already completed their curriculum and are summarized in the table below.

**Table 2. Summary of Educational Materials Development**

| Developer Name | Title | Grade Level | Learning Outcomes | Description |
|---|---|---|---|---|
| Valerie Salas | Climate Change in New Mexico | High School | Help students understand the consequences of climate change and the subsequent change in long-term weather patterns and its impact in New Mexico in terms of increased pollution, population density, and limited water resources. | Climate change and consequences of the changes. Students learn the connection between actions and their consequences, one such being the increased number of cars as well as increased usage leading to more pollution. |
| David Hailes | Green Energy Project | High School | Learn and apply electromagnetic concepts into building a generator powered by a Green Energy source like water, wind, tide, or wave action. Additional outcome of this project is the opportunity for students to utilize logical and scientific problem solving techniques | Research-based project that focuses on the impact of burning fossils fuels on our environment and the long-term sustainability of our current energy sources by involving students in hands on experiments using wind and solar power generation. |
| Theresa Apodaca | "Water" We Looking For? | Middle School | Students learn research techniques and use logical and analytical thought processes and inquiry skills by participating in school projects and assignments. | This course is designed for middle school students, teaching them to use analytical logic by analyzing water quality in the Rio Grande river and observing any increases in salinization levels. |
| Leigh Hedderman | Climate and Water - Earth Systems Interactions in the Southwest | High School | Help students increase their environmental literacy by building a deeper understanding of the Earth as a complex system of interacting parts and subsystems. | This is an introductory, interdisciplinary science course designed around understanding the "Big Idea" of the Earth as a system of complex, interacting parts. Students explore some of the biogeochemical cycles that connect major |

| Developer Name | Title | Grade Level | Learning Outcomes | Description |
|---|---|---|---|---|
| | | | | Earth systems as a foundation for understanding the effects of climate change on water resources. |
| Martha Holmen | A Semester Course in Energy for High School Students | High School | Increase student's awareness and interest in understanding the energy relationships between fossil fuels, and climate change, and improve students reading and math skills. | This course is designed to show the various Interactions of energy systems and its impact on climate change, e.g. thinning ozone layer as a direct correlation to the increase in methane gas in the atmosphere. |

In addition to the MST materials, two courses have been developed for future use in the Masters of Science Teaching Program.

**Java Course**: This course covers the programming and object-oriented techniques of Java. Students will learn about fundamentals of the Java language and syntax, common data types, testing and debugging, Java best practices, as well as object-oriented programming concepts such as classes, objects, methods, packages, and polymorphism. The course is practical, with many examples and programming exercises. Students taking this course will receive a solid basis in Object-oriented programming and the Java programming language.

**Data Literacy Course**: This course will teach students how to process, analyze and visualize the data. The course covers topics including data visualization, graph interpretation, dynamic and static data analyses, and data quality assurance/quality control. The students will learn to use a variety of tools for accessing, converting, and manipulating data.

***Connecting CI and Business***

In the original proposal, NM committed to broadening the impact of the Consortium's investments in CI to the business community in a model program that could be considered for adoption by the other two Consortium states. After several stakeholder meetings, the consortium leadership from NM determined the most effective strategy would be to focus on rural, small business entrepreneurs, a business segment that can play a significant role in the state's economic development yet generally lacks expertise in CI. In NM, these businesses are frequently related to art and culture. NM decided to partner with Fast Forward NM (FFNM), a program of the non-profit Global Center for Cultural Entrepreneurship (GCCE), for this work. FFNM had already invested in developing materials and processes for delivering training workshops for small business

entrepreneurs. These workshops introduce the entrepreneurs to basic web services and tools that can be used to increase their productivity and market their products. In addition, FFNM provides extra training and consulting services for selected cooperatives in using internet technologies for product development, marketing plans and sales.

The EPSCoR Track 2 project provided support for FFNM to offer these workshops in rural communities in New Mexico—Espanola (8 computer training classes, 70 participants), Silver City (12 computer training classes, 118 participants), Ohkay Owingeh Pueblo (4 computer training classes, 25 participants), and throughout the Navajo Nation (8 computer training courses, 469 participants). These communities are also the focus of CI investments through NM's C2 project. The levels of participation and number of courses offered (based on demand) far exceeded project expectations. Classes taught on the Navajo Nation were taught primarily in Navajo (Diné) using English training materials and native Navajo speakers. EPSCoR support enabled FFNM to partner with community-based organizations to bring trainings and individual support to small business owners and entrepreneurs.

In addition, FFNM hosted cyberinfrastructure guest speakers in Silver City (55 attendees), Espanola (40 attendees), and helped develop a business/community event in Silver City scheduled for August 2012. FFNM has also engaged with four businesses and a curriculum development specialist to demonstrate case studies of rural small business that have successfully used Internet tools to manage their enterprises. This work is ongoing. Similar work to develop and implement marketing plans using CI to reach new markets, improve revenues, and decrease marketing costs are underway for the benefit of rural small businesses. FFNM is using social media, video footage, and websites for these activities.

A key element of the program is the extensive grassroots outreach and partnership building they conduct. To date, they have created partnerships in each of the communities with myriad organizations including: Navajo Technical College, Thoreau Community Center, Sacred Wind Communications, Northwest New Mexico Council of Governments, Mimbres Region Arts Council, Silver City Small Business Development Center, Silver City Arts and Culture Council, Silver City Public Library, Northern New Mexico Connect, Ohkay Owingeh Public Library, Regional Development Council, Northern New Mexico College's Northern Pueblos Institute, REDI, and various small businesses.

A representative of FFNM attended the Cyberlearning Summit (described below) and presented information about their work at the 2012 Tri-State Annual meeting. Representatives of Idaho and Nevada EPSCoR have had follow-up discussions with FFNM to explore options for replicating the project in their states.

### *Broader Impacts - Cyberlearning*

- Provided information and funding for CI-related training for graduate students and faculty.
- Coordinated and hosted a Cyberlearning Summit for dissemination and sustainability.

- Revised and updated curriculum modules to support a teacher summer science institute in Nevada.
- Sustained Nevada's curriculum modules through adoption in Idaho (in progress).
- Developing three curriculum modules related to indigenous communities and climate change.
- Collaborating organization, McCall Outdoor Science School, updated a Cyberlearning website and is working to enhance site content and HIS database interface.
- Funded five new Supercomputing Challenge teams and five new teams in Project GUTS (Growing Up Thinking Scientifically) in New Mexico.
- Evaluated and organized on-line resources for climate data, visualization tools, and tutorials.
- Developed a web framework to allow teachers to use web-based instructional tools in their classrooms.
- With partners, provided CI-related teacher professional development.
- Delivered bi-lingual (either Spanish or Diné) computer trainings to over 680 participants, hosted CI guest speakers for close to 100 attendees, through support and partnership with FastForward NM.
- Implemented social media to benefit rural small business owners to reduce marketing costs.

## Diversity and Broadening Participation, including Institutional Collaborations

### Diversity and Broadening Participation

The Consortium is committed to improving access to CI for underrepresented groups and geographically disadvantaged populations. Overall, the project encourages broad participation by students from community colleges, women, underrepresented racial/ethnic minorities (Hispanic/Latino, American Indian or Alaskan Native, Black or African American, and Native Hawaiian or other Pacific Islander), people with disabilities and first-generation or low socioeconomic status students.

A Western Consortium Tri-State Diversity Working Group was formed at the 2010 Tri-State annual meeting. The Education, Outreach, and Diversity Coordinators from all three states successfully proposed and organized a Tri-State IWG focused on Diversity, which was convened in the fall of 2010. The IWG produced a Tri-State Diversity Strategic Plan in which six strategies are detailed with action items and timelines for each; the full plan is available on the Western Consortium website (see Resources at www.westernconsortium.org). The six strategies are:

1. **Engage Interest Early**: Engage the interest of URM students and women by providing information that allows them to explore and prepare for a career in the field.
2. **Early Research Experiences**: Enhance the retention and advancement of URM students and women by ensuring early research experiences, utilizing a reward system for students and faculty based on an analysis of their needs.

3. **Social Networking**: Facilitate the recruitment, retention, and advancement of URM students and women by designing, developing, and maintaining a social networking system that provides academic and social support for these students.
4. **Mentoring**: Develop the capacity of faculty members to be successful mentors for URM students and women by supporting professional development activities and by sponsoring appropriate rewards to recognize faculty contributions.
5. **Best Practice Research**: Systematically research approaches and best practices for under-prepared STEM-interested students and use data-driven analysis to better understand potential barriers for STEM-interested students
6. **Coordinated Efforts**: Facilitate coordinated action in the recruitment, retention, and advancement of URM students and women through a state (then regional) hub.

A Diversity Working Group session at the 2012 Tri-State Annual Meeting in Idaho revisited the plan and reported progress made in each of the six strategies. Progress to date includes:

- Development of a searchable database in NM that lists STEM programs, opportunities, and events for students, teachers, and members of the community; the database is modeled after the Idaho STEM Pipeline.
- Launch of social networking tools, including Facebook, for various programs in all three states.
- Development of a collaborative website to share resources and best practices for engaging and retaining URM and women in STEM.

Members of the Diversity Working Group continue to meet virtually to facilitate further implementation of the plan.

In addition, each state is working to broaden the participation of URM and women in CI and, more broadly, STEM, through the activities of the Cyberlearning component.

*Nevada*

In Nevada, the goal of increasing diversity and broadening participation is addressed primarily through the composition of the project leadership team (faculty, students, collaborators) and the recruitment of a diverse group of teacher participants that work in ethnically diverse schools that serve large numbers of Hispanic students. We have also included a collaborator (Mynster) who also works as a content developer on Climate Adaptation Mitigation e-Learning (CAMeL). CAMEL is developing an extensive, high quality, vetted collection of climate related educational materials that incorporate a broad array of cyber content types. The goal of CAMEL is to provide the opportunity for every college student to become educated about climate change and the personal, professional, and societal options for meeting the major challenges posed by this urgent problem. CAMEL is created by the Council of Environmental Deans and Directors (CEDD) of the National Council for Science and the Environment (NCSE) and supported by a grant from the National Science Foundation, Division of Undergraduate Education (NSF GRANT 0950396).

In addition, Green Valley High School (GVHS) in Henderson, Nevada serves as a formative evaluation site for cyberlearning materials that are developed in Nevada. Over the first three years of this project, five different science teachers (including one special education

teacher and a student teacher) and approximately 500 students from GVHS have participated. GVHS has a 41% minority student population with 17% of all students qualifying for free/reduced lunch and 8% with documented disabilities. GVHS has been ranked in the top 5% in Newsweek Magazine's "America's Top Public High Schools" for the past seven years.

*Idaho*

To enhance the retention and advancement of women and underrepresented students in early research experiences, the Track 1 Idaho EPSCoR REU Program was altered to target women and underrepresented students, including students from 2-4 year Idaho colleges. The program also offers an interstate university exchange option. Additions were made to the Idaho EPSCoR website to offer student professional development resources including, (1) "How to Create an Engaging Poster," (2) "How to Apply to Graduate School," and (3) "Broadening Participation of Native American Students in STEM." To strengthen mentoring, the Idaho EPSCoR website offers faculty professional development resources including, (1)"Handbook for Mentoring URM Students," (2) "ACCESS STEM – Disability Resources," and (3) "Faculty Mentoring Plan."

Idaho EPSCoR also increased coordination at a state level including coordination of a Diversity STEM meeting to address broadening participation of URM students in STEM. Idaho EPSCoR is part of a statewide planning committee, led by the Idaho State Board of Education, to work on the state's roadmap for STEM education. During the recent Idaho STEM Summit, Idaho EPSCoR served as lead for Goal 5 which is, "Promote equitable access to K-20 STEM opportunities to increase the diversity and success of students and workers entering STEM fields through the facilitation of effective recruitment, retention, and advancement strategies." Idaho EPSCoR is part of the writing team that will create the Idaho STEM roadmap for use at a State level.

Idaho STEM Pipeline, developed under the Track 1 award, is currently expanding to not only include additional programs on the website, but to develop a social media component to the site. Efforts are being made to identify new areas of growth for the Idaho STEM Pipeline that will help reach a broader audience and create greater access to URM students. Potential areas of growth were also discussed at the recent Idaho STEM Summit, including the possibility of creating an advisory board to the existing Idaho STEM Pipeline which would provide greater oversight and generate additional opportunities for expansion in Idaho.

*New Mexico*

Through our partnership with the Supercomputing Challenge and Project GUTS, NM has been able to support teachers and students who would not otherwise be exposed to the development these programs have to offer. Additionally, NM is working closely with NMT's Masters of Science Teaching (MST) program to offer professional development through the Summer Teacher's Institute and through a new AP Computer Science course development class. All of these curricula will be disseminated via NMT's EPSCoR website.

NM is also developing a class for teachers in NMT's MST program to prepare them to teach an AP Computer Science curriculum at their schools. This includes the topics of computational thinking, computational problem solving, and teaching programming and debugging in the Java programming language. Development of the course will be completed soon with execution and initial assessment coming in the fall of 2012 or spring of 2013. The MST program is estimating, based on inquiries from teachers, that approximately 30 teachers from throughout New Mexico will attend this professional development. EPSCoR will be supporting the initial execution of the professional development class, and the MST program will be taking over the support afterwards.

**Institutional Collaborations**

The project has engaged in institutional collaborations both within the Consortium and with institutions outside the Consortium.

*Collaborations among Consortium Institutions*

The project was set up with a management and research structure that facilitates collaborations among faculty from the different Consortium campuses (see diagram below in Management section). For example, researchers in Idaho, Nevada, and New Mexico have developed strong collaborations between UNM, UNR, UNLV, DRI, NMSU, NM Tech, ISU, UI, and University of South Carolina through the collaborative work in the *Interoperability* Component on model and data interoperability and the infusion of time series data products into the systems for both delivery and capability testing. Similarly, the Tri-State *Interoperability* activities have also continued to expand their connections with external institutions through training and knowledge transfer with NOAA and USGS, and collaborative proposal development with the USDA Forest Service AirFire team, the University of Texas in El Paso, and Kansas University.

Collaborations have also been fostered through the *Cyberlearning* Component. Institutional collaborations in Nevada involve the Curriculum and Professional Development Division of the Clark County School District (CPDD-CCSD), the Southern Nevada Regional Professional Development Program, and select schools from with CCSD. As of 2006, CCSD served a K-12 student population numbering more than 300,000 and ranked 5th largest in the United States. CCSD covers nearly 8,000 square miles (including the greater Las Vegas metropolitan area) and includes rural, suburban, and urban schools. In 2007, Hispanic student enrollment in CCSD reached majority status at 40%. The Southern Nevada Regional Professional Development Program (SNRPDP) is a state-supported program responsible for the design and delivery of professional development to teachers throughout the state of Nevada. The mission of CPDD-CCSD is to provide leadership and guidance for all stakeholders to increase student achievement through standards-based curricula, professional development, and educational support.

In New Mexico, the Supercomputing Challenge and Project GUTS are partnered with Sandia and Los Alamos National Labs, NMT, UNM, NMSU, New Mexico Highlands University, Eastern New Mexico University, NMSU-Dona Ana Community College, Northern New Mexico College, San Juan College, Santa Fe Community College, Computer Science Teacher's

Association, and the New Mexico Network for Women in Science and Engineering. The first five institutions of higher education listed above are all Hispanic Serving Institutions. Fast Forward New Mexico is working with a wide range of partners, including small businesses, libraries, chapter houses, and community centers.

In Idaho, MOSS is partnering with Idaho State University and two Twin Falls School District employees as well as the College of Southern Idaho and University of Idaho Extension. MOSS works with dozens of school districts in Idaho that engage hundreds of K-12 students each year in hands-on science learning experiences.

***Cyberlearning (CL) Summit***

Each of the states has developed CL tools related to the theme of water resources and climate change. Twenty-six (26) participants from all three states convened in New Mexico in January 2012 to explore synergies that exist among the projects. During the two-day CL Summit, representatives of each state led demonstrations of the K-12 CL materials and programs that had been developed or expanded with NSF EPSCoR funding, including the McCall Outdoor Science School (MOSS) in Idaho, Growing up Thinking Scientifically (GUTS) in New Mexico, and implementation of Climate Change Cyberlearning Curriculum Development (C4D) in Nevada. In addition to learning about the programs, a goal of the summit was to identify components of the projects that were suitable for scaling up and dissemination to the other states. During the summit, it became clear that the programs developed individually were synergistic and would likely provide even more effective learning opportunities for students by incorporating components across projects. As a result, CL leaders from each state contributed to a proposal to NSF's Cyberlearning: Transforming Education program (Capacity Building) that would support development of a research program to consider how the various approaches used by each program and their respective strengths could best be integrated and leveraged. Dr. Karla Eitel Bradley from the University of Idaho MOSS program, served as Principal Investigator for the proposal. The summit also resulted in several cyberlearning sessions that were offered at the 2012 Tri-State Meeting.

The Consortium also incorporated four other mechanisms to promote collaborations among the Tri-State Institutions: (1) Annual Tri-State Consortium Meeting; (2) Cyberinfrastructure Working Group; (3) Innovation Working Groups; and (4) Junior Faculty Leadership workshop.

***Tri-State Meeting***

Each year the Western Tri-State Consortium conducts an annual meeting of current NSF EPSCoR participants. The primary purpose for this meeting is to foster collaborations among the NSF EPSCoR RII projects and participants in our respective states and to identify common challenges and solutions related to the themes of our states' RII programs. The meeting agendas and presentation formats, facilitated sessions, working group breakouts, etc., are specifically and carefully developed to spur collaboration among program directors, cyberinfrastructure scientists, research scientists, education professionals, and outreach and diversity program coordinators. The meeting rotates among the three EPSCoR jurisdictions.

Nearly 200 researchers and educators from New Mexico, Nevada, and Idaho gathered for the 4th Annual EPSCoR Western Consortium Tri-State Meeting in Sun Valley, Idaho on April 3-5, 2012. The theme of this year's meeting, "Collaborations Connecting Climate Change Science, Education, and Policy," highlighted the connections that have been developing across institutions and disciplines throughout the consortium. Researchers shared the outcomes of their work, discussed implications and possible synergies between their efforts, and clarified questions that will guide their work into the future. The three-day meeting featured 12 concurrent sessions, keynote speakers, and a highly regarded student poster competition; the full agenda is available in Appendix A. In addition, there were Working Group meetings and workshop on Hydrologic Information Systems, Climate Modeling, and Systems Modeling, and C4D Educational materials. Presentations and electronic versions of 65 posters are available for viewing on the Tri-State Meeting website. Specifically, several cyberlearning sessions were offered including: Engaging Pre-and In-Service Teachers in Climate Change Literacy; a Cyber-Learning Panel; Nevada's Climate Change Cyberlearning Curriculum Development: History, Findings, and Future; Climate Education Resources; and Infrastructure for Cyberlearning. Faculty from within and outside the Cyberlearning Group presented at these sessions.

***Cyberinfrastructure Working Group***

The CI Working Group was formed in 2008 to leverage existing CI resources and expertise both nationally and in the tri-state region, to support climate change research, and to identify and evaluate interoperability standards and solutions that can be deployed regionally. While details on Year 3 accomplishments of the CI Working group are described in the Research Accomplishments section above, a few highlights are worth mentioning here. First, the Tri-State CI working group held several productive face-to-face meetings, one of which included collaborators from the LTER Network Office and NOAA in developing and further refining the metadata and data replication model being implemented between the three states. Second, the continuing technical exchanges between the Tri-State working group members have contributed to accelerated development of the CI capabilities within the three states – whether it is through software component collaboration (the DotSpatial coordination between ID and NV is an example of this), or discussions of the capabilities and limitations of specific technologies to support target interoperability standards.

***Tri-State Innovation Working Groups (IWG)***

Another mechanism for facilitating collaborations is the Tri-State's Innovation Working Group (IWG) Program, which supports collaborative, trans-disciplinary work by the three member states. The IWG provides a venue for engaging scientists and educators, along with key nationally and internationally recognized experts, to address the grand challenges that can transform science and education. This program supports multiple-day working group activities that are modeled after those hosted by the highly successful NSF-supported National Center for Ecological Analysis and Synthesis (NCEAS). The IWGs that convened during the performance period were held in Idaho and are described here:

*Carbon and Nutrient Dynamics in Semi-Arid Ecosystems, led by Dr. Marie-Anne de Graaf, Boise State University:* This IWG included seven faculty and students from BSU, DRI, NMSU, The primary goal of the "Carbon and Nutrient Dynamics in Semi-Arid Ecosystems" Innovation Working Group was to write a review paper addressing the uncertainties associated with soil C cycling in semi-arid and arid ecosystems in the northern hemisphere, and to use this paper as a foundation for development of a competitive proposal to be submitted to the National Science Foundation. The participants are in the process of writing a review paper, which should be completed this summer 2012. A pre-proposal was submitted to the NSF, Carbon dynamics in arid ecosystems: mechanistic responses to climate variability and climate change from microsite to landscape scales, in response to the RFP: DEB-Ecosystem Studies. If accepted, a full proposal will be written that sets out to evaluate how changes in precipitation will affect carbon cycling processes across desert ecosystems.

*The Role of Downscaling Methods on Climate Impact Modeling in Complex Terrain, led by Dr. John Abatzoglou, University of Idaho (awaiting final report):* The IWG spurred an effort to quantify the fractional uncertainty of climate change projections at local scales due to the choice of downscaling method. The group is conducting a coordinated inter-downscaling comparison building off the downscaling methodologies developed within the Tri-State consortium, and will be applying these data to both hydrologic and ecological models to better contextualize the choices of downscaling methods for assessing climate impacts in complex terrain. The IWG was designed to better address this gap in scientific knowledge that has both theoretical and practical implications, and to increase synergy between groups in the Tri-State consortium in preparation for the next round of models created for the fifth assessment report of the Intergovernmental Panel on Climate Change.

### *Junior Faculty Leadership Workshop*

The fourth annual NM EPSCoR Junior Faculty Leadership workshop continued a track record of success in providing training for early-career faculty and post-docs that enhances their leadership skills and increases their competitiveness for national-level funding opportunities. The three-day workshop in January 2012 focused on improving the communication skills and productivity of the participants. This year's agenda continued and expanded the highly successful "Communicating with Media" interactive session from past years and included additional sessions on effective teaching and mentoring as previous attendees requested.

Figure 4. Participants in the 2012 JFL Workshop

The workshop was held at the Valles Caldera National Preserve Science an Education Center, Jemez Springs, New Mexico. The remote location and residential program allowed for extensive informal networking and new collegial synergies among participants. Twenty-one individuals from 10 different institutions across the Tri-State region participated for all 3 days. The group consisted of 14 White, 5 Asian, 1 Native American or Alaskan Native, and 1 preferred not to respond. The gender distribution was 14 male and 7 female.

*Collaborations with Institutions Outside of the Consortium*
Consortium researchers collaborated with faculty from several universities and organizations outside the Consortium, including: U. South Carolina, U. Texas Austin, U. Texas, El Paso, and NCAR. The Model and Data Interoperability component team members have established numerous collaborations with agencies and institutions.

## Workforce Development

The Consortium's key *workforce development* efforts are being made through its C*yberlearning* activities at the K-12 and post-secondary levels. The Consortium is providing outreach and training in CI, which is enhancing research capabilities and workforce development in the sciences necessary for analysis and understanding of climate change. These activities are described in the *Cyberlearning* section, in the Research Accomplishments and Plans section above.

## Cyberinfrastructure

The Tri-State Cyberinfrastructure (CI) Working Group met in Coeur d'Alene, Idaho on the day preceding the National EPSCoR Meeting in the Fall of 2011 and spent 1 ½ days working out the details of the metadata model and data exchange strategy for implementation across the three Tri-State CI partners.

The planning and implementation discussions were continued at the 2012 Annual Tri-State meeting in a half-day CI Working group meeting, with a complementary open presentation of the data portal capabilities that have been developed in all three states, with a particular focus on acquiring user feedback from meeting attendees relating to the usability and desired features of the data portals in each state.

In addition, the Cyberlearning component has made contributions to the Consortium's CI, which also contributes to our communication and outreach efforts.

In Nevada, the cyberlearning portal (http://climatechange.education.unlv.edu) continues to be used in research and in development of curriculum materials. The courseware site (http://climatechange.education.unlv.edu/moodle) hosts high school courses that are using the materials, offers open-access to developed materials, and serves as a dissemination point for project materials and scholarship.

In New Mexico, the NMT EPSCoR website (http://www.cs.nmt.edu/~epscor/) serves as a clearinghouse for cyber-education links to climate change datasets, visualization and data analysis tools and tutorials, grants, scholarships, and training opportunities. The site also serves as the focal point for disseminating the curricula developed by EPSCoR-supported MST students and the classroom management web framework currently under development. The framework will allow teachers to utilize the additions to the CI in NM to manage their classes from the web. While extensible in multiple ways, it maintains a low barrier to entry by requiring no programming to set up or operate. The framework is being designed to work with Google's free App Engine infrastructure. By utilizing Google's App Engine, teachers from schools without the necessary hardware and support to host course infrastructure will be able to deploy and use it with no cost. This framework will be available from NMT's EPSCoR web site and an announcement will appear on the web site as soon as it is available.

## Outreach and Communication

The Consortium has a number of outreach and communication mechanisms. These include the Annual Tri-State Consortium Meeting, Cyberlearning activities, each state's EPSCoR web site, as well as the Western Consortium website and presentations made at national scientific meetings.

A centerpiece for communication and outreach is the annual Tri-state Consortium meeting, which facilitates collaboration and information sharing between our states and was described above. The Western Tri-State Consortium website, linked to each state's individual website, provides information about Consortium activities and opportunities as well as an archive of Consortium accomplishments, presentations, and products (Figure 5).

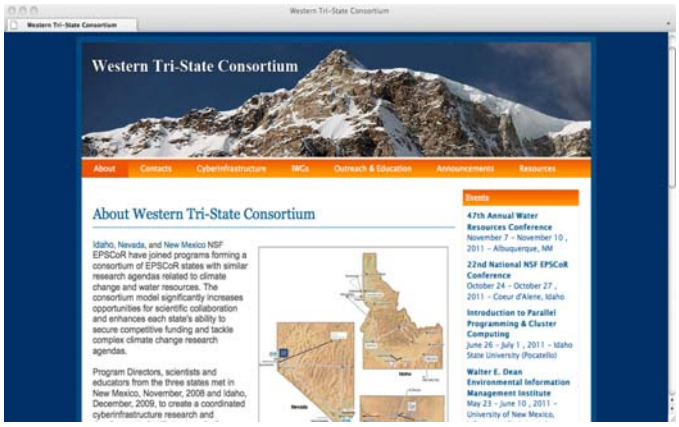



Figure 5. Screen shot of the Western Consortium website

The Tri-state annual meeting also provided an opportunity to pilot a meeting blog on which participants were invited to discuss their experiences at the meeting as well as their research interests more broadly. The outreach coordinators for each state are further studying the use of blogs and other social networking tools for Consortium outreach and communication.

Outreach and communication is embedded in all of the *Cyberlearning* activities described above under the Research Accomplishments and Plans section. This includes outreach to middle and high school teachers, stakeholders, RII participants, and underrepresented groups through the CI Training program, the development and dissemination of educational materials (e.g., through the MOSS and UNLV programs), and through CI extracurricular programs (e.g., GUTS, National Supercomputing Challenge). In addition, the Idaho Cyberlearning state lead, Dr. Nancy Glenn, hosted 15 Idaho middle school science students to learn hands-on visualization techniques, using infrastructure provided by this award.

### *Presentations*

The table below lists many of the numerous presentations Consortium researchers and educators made of their work throughout the year. **Not** included are the more than 65 presentations and 55 student posters and 12 faculty/postdoc posters from the Tri-State meeting; information about these are available on the 4th Annual Western Consortium Tri-State Meeting post conference website.

**Table 3. Year 3 Presentations**

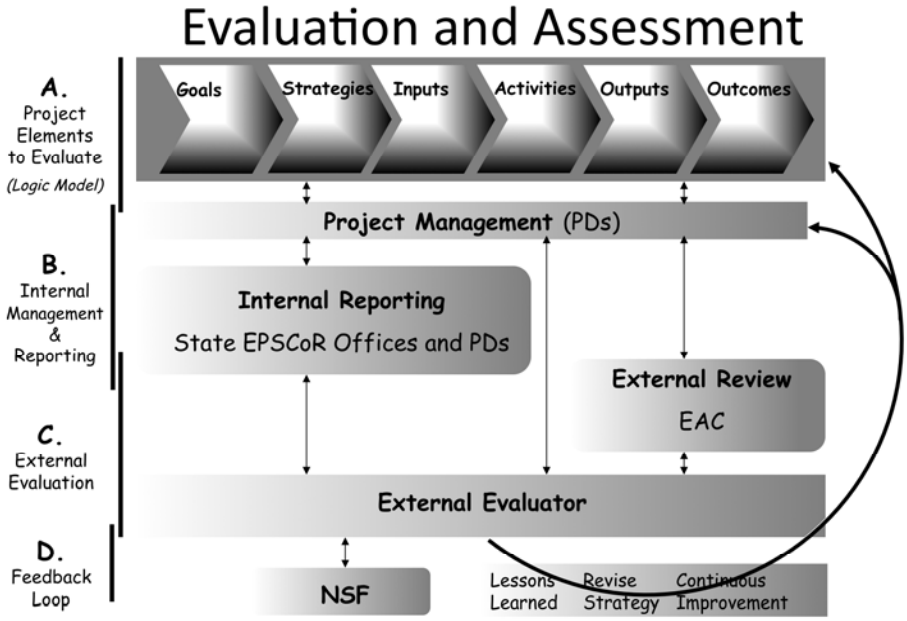
| State | Presentation Type | Presenter(s) | Event | Title |
|---|---|---|---|---|
| NV | Paper presentation | **Schrader, P. G.**, Deniz, H., & Keilty, J. (2012, March) | Annual meeting of NARST, March 25 - 28, 2012, Indianapolis, ID. | Video Games In Middle School Science: Overcoming Spore's Flaws To Promote Conceptual Understanding. |
| NV | Paper presentation | **Schrader, P. G.**, Deniz, H., & Keilty, J. (2012, March). | Annual meeting of the Society for Information Technology and Teacher Education, March 5-9, 2012, Austin, TX. | Breaking SPORE: Aligning Video Game Affordances to Science Pedagogy. |
| NV | Paper presentation | **Schrader, P. G.**, Strudler, N., & Asay, L. (2012, March). | Annual meeting of the Society for Information Technology and Teacher Education, March 5-9, 2012, Austin, TX | The Pathway to Nevada's Future Project: Evaluating Two Years of Online Professional Development. |
| ID | Poster presentation | Moore, C.*, Olsoy, P., Gertman, V., Mitchell, J., **Glenn, N.**, Joshi, A., **Shrestha, R.**, Spaete, L., Norpchen, D., Pernice, M., Whiting, E., Grover, S., Lee, R., Anderson, J., Busche, C., | American Geophysical Union Meeting, San Francisco, CA, December 2011<br>Abstract published: Eos Trans. AGU, Fall Meet. Suppl., Abstract EP41A-0600 | Discovering new methods of data fusion, visualization, and analysis in 3D immersive environments for hyperspectral and laser altimetry data, |

| | | | | |
|---|---|---|---|---|
| NM | Poster Presentation | Nyman, M., Elwein, A., Connealy, S., **Daniel, M** | American Geophysical Union Meeting, San Francisco, CA, December 2011 | Using Data-Rich Instruction for Climate Change Education: Roadblocks and Pathways |
| NM | Poster Presentation | Nyman, M., Elwein, A., Connealy, S., Strong, M., **Daniel, M** | Geological Society of America , October 2011; Geological Society of America Abstracts with Programs, Vol. 43, No. 5, p. 405. 2011 | Investigating and improving the science and data literacy of pre-service elementary educators |
| NV | Invited Talk | **Dascalu S.M**. | Nevada Climate Change Seminar Series, University of Nevada, Las Vegas, September 7, 2011. | Imagine a million file cabinets of climate data: The Nevada Climate Change Data Portal |
| NV, NM, ID | Poster Presentation | **Patel, J., Dascalu, S**., **Harris, F., Benedict, K., Gollberg, G. and Sheneman, L** | American Geophysical Union Conference (AGU-2011). San Francisco, CA, December 2011. | Visual Mapper for Data and Model Interoperability. |
| NM, ID, NV | Poster Presentation | **Benedict, K., Gollberg, G., Sheneman, L., and Dascalu, S.M.** | American Geophysical Union Conference (AGU-2011). San Francisco, CA, December 2011 | Advances in Metadata Generation and Applications to Earth Sciences |
| NV | Invited Talk | **Dascalu, S.M.** | University of Milano-Bicocca, Milan, Italy. January 11, 2012. | Cyberinfrastructure Developments for Climate change science and education in Nevada |
| NV | Invited Talk | **Dascalu, S.M. and McMahon, M., Jr.** | UNR College of Engineering Advisory Board Meeting, March 30, 2012 | Nevada Cyberinfrastructure for Climate Change Research |
| NM, ID, NV | Poster Presentation | **Karl Kent Benedict; Gregory Gollberg; Luke Sheneman; Sergiu Dascalu** | American Geophysical Union Fall Meeting, San Francisco, CA. December 5-9, 2011 | Coordinated Earth Science Data Replication Enabled Through ISO Metadata, Version Control, and Web Services |
| NM | Poster Presentation | Huang, Qunying; Phil (Chaowei) Yang; **Karl Kent Benedict** | American Geophysical Union Fall Meeting, San Francisco, CA. December 5-9, 2011 | Utilizing High Performance Computing and Loosely-Coupled Nested Models to Enable the Computability of Dust Storm Forecasting |
| NM | Poster Presentation | Hudspeth, William B.; **Karl Kent Benedict**; Laura Gleasner; Renzo Sanchez-Silva | American Geophysical Union Fall Meeting, San Francisco, CA. December 5-9, 2011 | New Mexico EPSCoR – Challenges of Integrating Diverse Water- Related Climate Data Into an Interoperable Geospatial |

| | | | | |
|---|---|---|---|---|
| | | | | Infrastructure |
| NM | Poster Presentation | Kempler, Steven; **Karl Kent Benedict**; Pietro Ceccato; Meredith Golden; Susan Maxwell; Stanley Morain; Radina Soebiyanto; Daniel Tong | American Geophysical Union Fall Meeting, San Francisco, CA. December 5-9, 2011 | The Increasing Use of Remote Sensing Data in Studying the Climatological Impacts on Public Health |
| NM | Presented Paper | Goodrich, David C.; David Brookshire; Craig Broadbent; Mark D. Dixon; L. A. Brand; Jennifer Thacher; **Karl Kent Benedict**; Kevin E. Lansey; Juliet C. Stromberg; Steven Stewart; Molly McIntosh | American Geophysical Union Fall Meeting, San Francisco, CA. December 5-9, 2011 | Coupled hydrological, ecological, decision and economic models for monetary valuation of riparian ecosystem services |

## Evaluation and Assessment

The project's management team works in concert with the External Evaluator (Lisa Kohne) and an External Advisory Committee to monitor how well the project is moving towards its goals. The External Evaluator uses formative and summative evaluation processes and provides quarterly evaluation reports to the project management team. In addition to the external evaluator, our project's *evaluation* and *assessment* component includes a seven member External Advisory Committee (EAC) that meets annually. The third EAC meeting took place in February 2012 in Santa Fe, New Mexico. A summary of, and outcomes from, the meeting are detailed in the attached EAC report. A schematic of the project's evaluation and assessment program is shown below.



## Sustainability and Project Outputs

*Sustainability* efforts are being accomplished in several ways. The first is by commitments to long-term support by individual states and institutions for Track 2 activities. The connectivity and broadband improvements accomplished in year one are being maintained by each state/institution.

Sustainability of the *Cyberlearning* Component has focused on development of partnerships and strengthening existing partnerships for leveraging activities. The Cyberlearning component has submitted a proposal to NSF (see above). The proposal was submitted under "Cyberlearning: Transforming Education" in the Capacity-building track to build partnerships and research capacity within the EPSCoR Tri-State Consortium. All three states participated in this effort, which, if funded, will bring the teams together to integrate their independently developed cyberlearning materials in a way that would maximize the strengths of each and make use of the complementary strengths of the other programs. The team also hosted a Cyberlearning Summit

These activities were followed with additional developments at the tri-state meeting. Consortium participants continue to partner with MOSS in developing and disseminating educational material that will be leveraged to increase additional support of activities in the future. They have also strengthened the partnership with the Supercomputing Challenge and Project GUTS to incorporate CI materials into existing programs, which will sustain the impact long after the end of this project.

New proposals that make use of and provide continued CI support have been submitted, or are in the process of being submitted this year. Proposals submitted by Consortium members in Year 3 are shown below.

Table 4. Year 3 Proposals Submitted

| Funding Agency | Title | PI/Co-PI | Amount | Status |
|---|---|---|---|---|
| NSF | CI:TEAM Demo: Adventure Learning through Water and MOSS, Award #1135577 | Miller, Brant; Bradley Eitel, Karla; Eitel, Jan | $170,811 | Funded, Start Date 1/1/12 |
| National Science Foundation Geomorphology and Land Use Dynamics Program | Water Vapor Isotopic Measurements on the Chajnantor Plateau, Chile and Implications for Subtropical Humidity Dynamics | Galewsky (UNM) | $334,132 | Funded, Start date 4/15/2012 |
| National Science Foundation | Collaborative Research: CI-Team Diff: The Virtual Learning Commons: STEM Research Communities | McConnell, Jarjorie; Vanderbilt, Kristin; Benedict, Karl, Brady, Kevin | $133,923 | Funded, Start Date 9/15/2011 |

| | | | | |
|---|---|---|---|---|
| | Learning about Data Management, Geospatial Informatics, and Scientific Visualization | | | |
| Bally Technologies | Bally-sponsored Senior Project in Computer Science and Engineering | S. Dascalu (UNR)-PI | $10,300 | Funded |
| NSF | CAP: Building Capacity for Cyberlearning in Idaho, Nevada and New Mexico | Karla Eitel,; Shrader, PG; Hougham, Robert; Daniel, Mary Jo; Lee, Irene | $49,991 | Pending |
| NSF - EHR-Cyberlearning: Transformimg Education | Designing Effective Web-based Simulations for Sustainability Learning and Engagement | Stave & Crippen (UNLV) | $550,000 | Pending |
| NSF - EHR-Discovery Research K12 | Collaborative Research: Web Application Composition to Power Up CSTA Curriculum | Tsai, Chen, & Archambault (ASU); Crippen (UNLV) | $1.9 Million | Pending |
| NSF | Collaborative Research: Large-Scale Modeling and Real-Time Simulation of Brain Dynamics and Interaction | F. Harris (UNR)–PI<br>S. Dascalu(UNR)-CoPI | $623,000 | Pending |
| NSF EPSCoR | From Climate Change Portal to Nevada Data Center for The Environment, Water and Energy (pre-proposal) | S. Dascalu (PI) with 23 co-PIs | $15,000,000 | Pending |
| NASA EPSCoR | A Highly Automated Platform for Continuous Monitoring of Astronaut Health and Performance in Space Exploration Missions | S.Latifi (UNLV) PI<br>F. Harris (UNR) CoPI<br>S. Dascalu (UNR) CoPI | $750,000 | Pending |
| NASA | Earth Science Data Services and Information Delivery for Enhanced Wildland Fire Related Air Quality Decision Support | K. Benedict (UNM, PI)<br>G. Gollberg (UI, Co-PI)<br>N. Larkin (USFS, Co-PI) | $159,132 | Pending |
| NASA | A Robust Collaboration Infrastructure to Detect and Address Volcanic Ash Effluents Using NASA and other Data for a Safer Air Transportation System in Alaska | R. Ameller (StormCenter Inc., PI)<br>K. Benedict (UNM, Co-PI) | $55,000 | Pending |

| | | | | |
|---|---|---|---|---|
| ONR | Brain Modeling and Simulation at UNR (tentative title) | F. Harris (UNR) PI<br>S. Dascalu (UNR)-CoPI | $900,000 | In preparation (to be submitted July 2012) |
| NSF | TBD (for NSF BIGDATA Program Solicitation) | S. Dascalu (UNR, PI)<br>F. Harris (Co-PI) | $2,500,000 | To be submitted June 2012 |
| National Science Foundation Geomorphology and Land Use Dynamics Program | Geomorphic Constraints on the Climate History of the Arid Chajnantor Plateau, Northern Chile: Interations between regional subtropical climate and high-altitute glacial landscapes | Galewsky (UNM) | $275,000 | Declined |

The third mechanism for sustainability is through creation of new partnerships and strengthened collaborations. Collaborations within the Consortium have been greatly strengthened as the result of the Annual Tri-State Meeting. Some of these collaborations have led to successful Innovation Working Group projects, and proposal development and submissions to Federal agencies. Other collaborations are detailed above in the Institutional Collaborations section. National partnerships developing in Year 3 include NSF-funded programs CUASHI, CREST, CZO, and CYBER-ShARE.

Sustainability of CI developments relating to the *interoperable* data archive in New Mexico have been accomplished in close collaboration with New Mexico's Resource Geographic Information System (NM RGIS), the geospatial data clearinghouse for the state of New Mexico. NM RGIS has a long-standing history (18 years) as the state clearinghouse and is a stable platform through which the science data products of the EPSCoR project will be continuously published beyond the funding window provided by NSF for the current RII. This partnership and integration of science data into the RGIS system will provide long-term sustainability for availability of products for years to come. Also, the development of the www.hydrodesktop.org web site – where all hydrologic information systems-related development associated with this project is being presented in an open source fashion – is focused on fostering collaborative development of the system with expected long-term sustainability by building a large group extending beyond the EPSCoR team.

**Seed Funding and Emerging Areas**

Seed funding to develop interdisciplinary and inter-institutional proposals and publications across states is being funded by the Consortium's Innovation Working Group Program. This program and groups that received IWG funding in year three are described above in the Institutional Collaborations section of the report. Seed funding is incorporated into the Cyberlearning Component through the sponsorship of CI training support for

Consortium participants, which is described in more detail above in the *cyberlearning* part of the Research Accomplishments and Plans section.

**Human Resources Development**
The project's human resources development activities and outcomes include recruitment and retention of new postdoctoral fellows, students, and technicians, workforce development, and workforce and education activities. These activities are described in prior sections of this report.

**Leveraging NSF Programs**
Linkages, coordination, and collaboration with other NSF-funded programs are occurring at the component level of the project. Primary leveraging in the *Interoperability* Component is through our involvement in the NSF-funded Consortium of Universities for the Advancement of Hydrologic Sciences (CUAHSI) Hydrologic Information Systems (HIS) project, which we are using extensively to support the point observation data interoperability work in this project. Also, the *Interoperability* group is leveraging EDAC's emerging collaboration with the CYBER-ShARE program at the University of Texas, El Paso, which has created a connection with NSF's CREST program, as CYBER-ShARE is funded through this program. As noted above, this collaboration has led to new proposals to NSF and NASA programs, two of which have now been funded, that provide support for semantic annotation of scientific workflows and products.

Each of the states is also leveraging their RII C2 awards for improving intra- and inter-campus connectivity.

In *Idaho,* the C2 grant is resulting in improved connectivity at several 2-year and 4-year colleges, including Lewis-Clark State College, North Idaho College, and College of Southern Idaho. The improved internet and video infrastructure provided by the C2 grant, as well as EPSCoR-catalyzed collaborations, are making it easier for university faculty involved in both Track 1 and Track 2 RII activities to work with college faculty to integrate water resources and climate change research topics into educational activities. An example of this is Dr. Rick Allen, who leads a Track 1 hydro-climatology research component, utilizes connectivity upgrades at the UI research station at Kimberly, Idaho, and is developing collaborations with College of Southern Idaho instructors (C2) for integration of research and education. The participation of College of Southern Idaho faculty at the recent Tri-State meeting has further encouraged synergy among our projects and institutions.

*New Mexico* has focused its C2 efforts on improving connectivity at two regional colleges and a tribal college. The Track 2 activity connecting the state's CI to industry through collaboration with Fast Forward New Mexico (described above) specifically targets the communities in which these colleges are located. Additionally, the education outreach efforts of the NM C2 award focus on increasing the use and providing content for the educational gateways that were installed as described in the Connectivity component.

*Nevada's* C2 major connectivity improvements were installed early in 2012. These improvements build on those funded by the Track 2 project with upgrades that increase

bandwidth in key locations of the system, and by leveraging Track 2 training programs in high performance computing. Together, C2 and Track 2 connectivity and broadband enhancements will promote communication and collaboration within Nevada as well as the Western Tri-State Consortium. In addition, a MacBook Learning Lab, purchased with Nevada C2 funds, is being used by 200 students at Green Valley High School in Henderson NV to access the Climate Change Cyberlearning Curriculum Development (C4D) website - developed as part of Track 2 - to investigate the impacts of climate change on the Great Basin region and to understand sustainable living.

## Management Structure

### EPSCoR governing committee meetings and relevant actions

*Idaho*
The Idaho EPSCoR Committee annual meeting was held in October 2011 following the National EPSCoR Conference in Idaho. The PI presented the Committee with an overview and update of progress on the Track 2 RII. EPSCoR Committee members met with their counterparts from NV and NM at the National Conference, and reported the Consortium's desire to sustain collaborations. No official actions relevant to the Track 2 RII were needed or taken.

*Nevada*

The Nevada EPSCoR Advisory Board was scheduled to meet on January 20th, 2012, but the meeting was cancelled due to a Special Session called by the NSHE Board of Regents on that day. A four person sub-section of the Advisory Board met three times (September 23, 2011, March 23, 2012, and April 9, 2012) to discuss and help guide the approach and development of pre-proposals for the next Track-1 RII proposal that will be submitted in 2012.

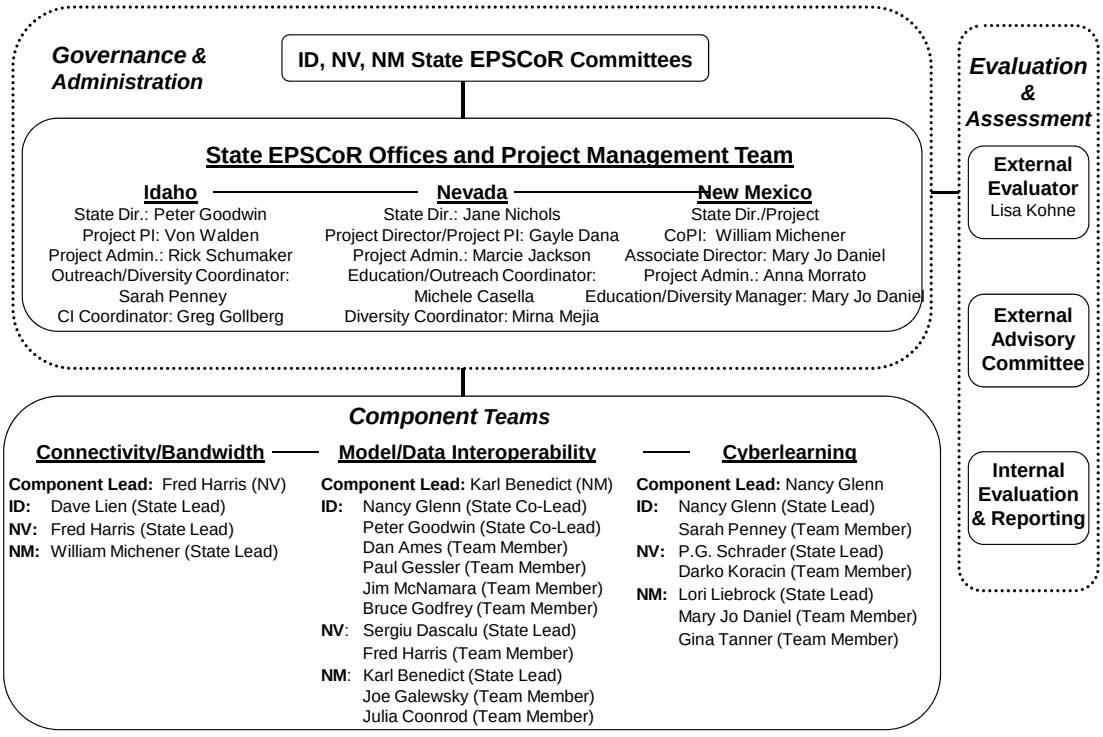
*New Mexico*
The New Mexico State EPSCoR Committee met in November 2011 and June 2012. At both meetings they reviewed Track 2 progress to date as well as feedback from external advisory and evaluation reports. Plans and timelines for development of the next RII proposals were discussed.

*All*
State Committee member representatives held a special session at the 22nd National EPSCoR Meeting in Fall 2011. Representatives from the tri-state governing committees discussed opportunities for continued collaboration beyond the period of this award.

### EPSCoR Management Team Meetings and Actions

The project *management structure* (shown in the diagram below) is designed to encourage interaction among the three states and the various components. It includes the Management Team (State Directors, PI, Co-PIs, Project Administrators, and Education,

Outreach, and Diversity Coordinators), the Component Team (Component Leads, State Leads, and component members), and Evaluation and Assessment (External Evaluator, External Advisory Committee, and Internal Reporting). To encourage effective project *communication* and *management*, there have been monthly Leadership meetings (consisting of the PI, Co-PIs, and Component Leads), as well as monthly meetings of Component members. Most meetings have occurred online via Webex or GoToMeeting. In Year 3, New Mexico and Nevada added communication specialists to their staff to assist with public outreach activities, and NV employed a Diversity Coordinator. In Year 3, two individuals in NV left the project. Dr. Kent Crippen, who took a faculty position at the University of Florida, was replaced by Dr. PG Schrader on the Cyberlearning Component. NV also replaced Project Administrator Pam Levins by hiring Marcie Jackson.




## Institutional Affiliation and Demographics

The project's leadership and management structure consists of state EPSCoR and NSF EPSCoR Project Directors, Track 2 Project PI and Co-PIs, Component Leads, and State-Specific Component Leads. The state breakdown is: ID (8), NV (7), and NM (5). The leadership and management team is distributed among eight institutions: University of Idaho (7), Idaho State University (1), Nevada System of Higher Education (3), Desert Research Institute (1), University of Nevada, Reno (2), University of Nevada, Las Vegas (1), University of New Mexico (4), New Mexico Tech (1). Females make up 40% of the leadership and management team. There is one Native American and the rest of the

leadership and management team are White. Please see the table below for a detailed breakdown.

**Table 5. Institutional Affiliation and Demographics of Track 2 Leadership and Management Team**

| Title | State | Name | Institution | Male | Female | Underrepresented Race/ Ethnicity |
|---|---|---|---|---|---|---|
| State Director | Nevada | Jane Nichols | NSHE | | 1 | |
| Project Director and Project PI | Nevada | Gayle Dana | DRI | | 1 | |
| State and Project Director Model & Data Interoperability State Co-Lead | Idaho | Peter Goodwin | UI | 1 | | |
| State and Project Director Connectivity State Lead | New Mexico | William Michener | UNM | 1 | | |
| Associate NSF EPSCoR Director | New Mexico | Mary Jo Daniel | UNM | | 1 | |
| Project Co-PI | Idaho | Von Walden | UI | 1 | | |
| Project Administrator | Nevada | Marcie Jackson | NSHE | | 1 | |
| Project Administrator | Idaho | Rick Schumaker | UI | 1 | | |
| Project Administrator | New Mexico | Anna Morrato | UNM | | 1 | |
| Education, Outreach, & Diversity Administrator | Nevada | Michelle Casella | NSHE | | 1 | |
| Education, Outreach, & Diversity Administrator | Idaho | Sarah Penney | UI | | 1 | 1 |
| Connectivity Component and State Lead | Nevada | Fred Harris | UNR | 1 | | |
| Connectivity State Lead | Idaho | Dave Lien | UI | 1 | | |
| Model & Data Interoperability Component and State Lead | New Mexico | Karl Benedict | UNM | 1 | | |
| Model & Data Interoperability State Co-Lead Cyberlearning Component and State Lead | Idaho | Nancy Glenn | ISU | | 1 | |
| Interoperability Co-Lead | Idaho | Greg Gollberg | UI | 1 | | |
| Model & Data Interoperability State Lead | Nevada | Sergiu Dascalu | UNR | 1 | | |
| Data Manager | Idaho | Luke Sheneman | UI | 1 | | |
| Cyberlearning State Lead | Nevada | PG Schrader | UNLV | 1 | | |
| Cyberlearning State Lead | New Mexico | Lori Liebrock | NMT | 1 | | |
| Summary of Demographics | | | | 12 | 8 | 1 |

**Technical Assistance by other outside agents, e.g. consultants**

There was no significant technical assistance by other outside agents in year three, other than by the external evaluator reported above.

## Jurisdictional and Other Support

*Idaho*

In Idaho, the ID EPSCoR staff administers the NSF EPSCoR projects, including this Track 2 award. A portion of the staff effort is provided through non-federal state support for the Idaho EPSCoR program. Idaho EPSCoR resources for office space, communications, and videoconferencing are also provided.

*Nevada*

Financial and administrative assistance to the project is provided by the Nevada EPSCoR Office (NEO), which administers all of the state EPSCoR programs. Key personnel within the Administrative Management Team include: Marcie Jackson (full-time NSF EPSCoR Project Administrator) responsible for budget administration, coordination with the NSHE institutions' research offices, collecting baseline information, documenting accomplishments of project milestones, RII evaluation activities and general administration of sub-awards. Michele Casella (full-time NSF EPSCoR Research Administrator) coordinates education outreach programs, and statewide student solicitations, and works with faculty to increase diversity for project components. Mirna Mejia, full-time Diversity Coordinator, and full-time Communications Specialist, Martha Delgado, are responsible for information and updates for the Web developer, designs brochures for specific projects, works with the NSHE PR office for all press media relations, and works with the campus PR staff to incorporate NSF EPSCoR highlights for faculty, staff, and students. NSHE has video conferencing facilities that also allow file sharing and display of software presentations simultaneously between parties remotely located.

*New Mexico*

In New Mexico, the NM EPSCoR state office administers NSF EPSCoR programs. The State Office provides meeting and collaboration space, including access to video and web conferencing facilities.

Jurisdictional support for the individual project components include:

Connectivity Component: Strategic planning began at the jurisdictional level before this RII was funded and will continue to be supported after the project is completed through a variety of means. In *Nevada*, assessment of needs was performed by the universities and NevadaNet. In *New Mexico,* it was done by the New Mexico's Computer Applications Center (NMCAC), and in *Idaho* it was done by the state EPSCoR committee in collaboration with the Higher Education institutions.

Data and Software Interoperability Component: The *Idaho* research team continues to make extensive use of the facilities at the Department of Energy sponsored Center for Advanced Energy Studies in Idaho Falls, ID. *New Mexico's* team makes continuing use of the computational resources housed at the Earth Data Analysis Center, and with the addition of a new data storage system acquired as part of EDAC's participation in the UNM Research Storage Consortium, UNM's Center for Advanced Research Computing. The Computer Science Department at UNR in Nevada provides office and laboratory space for faculty, postdocs, and graduate students involved with Track 2.

## Unobligated Funds

The following is a summary of the funds projected to be unobligated at the end of the current performance period ending August 31, 2012.

Table 6. Unobligated Funds

| | Awarded | Obligated | Unobligated | %Unobligated |
|---|---|---|---|---|
| **Idaho** | $666,666 | $601,748 | $64,918 | 9.7% |
| **Nevada** | $666,667 | $612,190 | $54,477 | 8.9% |
| **New Mexico** | $666,665 | $681,555 | ($14,890) | (2.2%)* |

*NM Obligations exceeded budget due to expenditures of balances carried forward from previous years.

## 3. Award Specific Terms and Conditions.

The Consortium's Track 2 project has two award specific terms and conditions.

*1. Obtain from the school board or comparable authority responsible for the schools considering participation in the project, written approval prior to involvement of pre-college students in pre-college education research and development, pilot-testing, evaluation, and revision of experimental and innovative pre-college curriculum.*

Not applicable in year three

*2. Include in every publication, testing, or distribution agreement involving instructional materials developed under this award (including, but not limited to, teachers' manuals, textbooks, films, tapes, or other supplementary material) a requirement that such material be made available within the school district using it for inspection by parents or guardians of children engaged in educational programs or projects using such material of that school district.*

Not applicable in year three

## 4. Experimental/Computational Facilities

No major equipment was acquired with Track 2 funds in year three. There have been no usage fees paid with NSF RII money for accessing other NSF-funded shared facilities and networks in Nevada, Idaho, or New Mexico. However, Idaho EPSCoR staff in Idaho helped install and leverage nearly $650,000 worth of hardware purchased by the Northwest Knowledge Network and the Idaho National Laboratory. Their join investment results in the deployment of 500 terabytes of high performance, geographically distributed data storage infrastructure in Idaho. This server and storage equipment was completely deployed in March of 2012.

## 5. Publications

See NSF FastLane for a complete list of each state's publications relating to the Track 2 award. The list of Year 3 publications is provided below.

Table 7. Year 3 Publications

| | | |
|---|---|---|
| Miller, B.G., Hougham, R.J., & **Eitel, K.B**. | *The practical enactment of adventure learning: Where will you AL@?* | 2012 Manuscript submitted for publication. |
| **Eitel, K.B.,** Hougham, R.J., & Miller, B.G. | *Upload/download: Empowering students as science communicators* | 2012 Science Scope. Manuscript submitted for publication |
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| Adrienne Breland, Harpreet Singh, Omid Tutakhil, Mike Needham, Dickson Long, Grant Hennig, Roger Hoang, Torbjorn Loken, **Sergiu M. Dascalu, Frederick C. Harris, Jr.** | A GPU Algorithm for Comparing Nucleotide Histograms | accepted at the International Conference on Software Engineering and Data Engineering (SEDE-2012), Los Angeles, CA, June 2012. |
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| **Lee, Irene** | CS Learning is critical in K-8 | Accepted for the Computer Science Teachers Association – CSTA Voice, June 2012. |

## 6. Honors and Awards

The following awards and honors were given to RII participants in year three:

- Karl Benedict – Elected as President of the Federation of Earth Science Information Partners.
- Irene Lee, Director of Project GUTs, received the Educator Award from the National Center for Women and Information Technology (NCWIT) Aspirations in Computing.
- Mary Jo Daniel, Associate Director of NM EPSCoR, received the 2011 Service to Science Award from the New Mexico Science Teachers Association.

## Highlights (see Appendix C)

## Appendix A


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| Limelight C |
| Camas |
| Lupine |
| Aspen |
| Limelight Promenade |

**4th Annual NSF EPSCoR Western Consortium**
**Tri-State Meeting**
Sun Valley, ID

**MONDAY, April 2, 2012**

| | | | |
|---|---|---|---|
| 1:00 pm - 5:00 pm | Idaho CI Working Group Meeting (Camas) | Reserved for Idaho EPSCoR (Lupine) | Developing a Western Tri-State Common Curricula Collection Leigh Hedderman (NM) (Aspen) |
| 5:00 pm - 7:00 pm | Registration (Limelight Promenade) | | |
| 6:30 pm - 7:30 pm | Welcome Reception (Limelight C) | | |

# 4th Annual NSF EPSCoR Western Consortium Tri-State Meeting

Sun Valley, ID

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| Opera House |
| Continental |
| Limelight A |
| Limelight B |
| Limelight C |
| Limelight Promenade |

## TUESDAY, April 3, 2012

| | | | |
|---|---|---|---|
| 7:00 am - 12:00 pm | **Registration** (Limelight Promenade) | | |
| 7:00 am - 8:00 am | **Breakfast Buffet** (Limelight B) | | |
| 8:00 am - 9:45 am | **Welcome Remarks** Peter Goodwin, Idaho EPSCoR<br>**Plenary Session** Lilian Na'ia Alessa, University of Alaska "Kaitiakitanga: New Approaches for Water, Energy and Societal Sustainability" (Limelight B) | | |
| 9:45 am - 10:15 am | **Networking Break** (Limelight B) | | |
| 10:15 am - 12:00 pm | **Building Sustainable Native Communities** Chair: Bennie Francisco (NM) (Limelight A) | **Interface of Hydrology, Biogeochemistry, and Ecology in Riverine Systems** Chair: Becky Bixby (NM) (Limelight C) | **Engaging Pre-and In Service Teachers in Climate Change Literacy** Chair: Paul Buck (NV) (Continental) |
| 12:00 pm - 1:30 pm | **Lunch**<br>**Tri-State Cyberlearning Panel** Chair: PG Schrader (NV) (Limelight B) | | |
| 1:30 pm - 3:30 pm | **Nevada's Climate Change Cyberlearning Curriculum Development: History, Findings, and Future** Chair: PG Schrader (NV) (Limelight A) | **Birds-of-a-Feather (BoF): Using Social Media and Visualization to Communicate Science** Chair: Martha Delgado (NV) (Limelight C) | **Advances in Climate Modeling** Chair: John Abatzoglou (ID) (Continental) |
| 3:30 pm - 4:00 pm | **Break** | | |
| 4:00 pm - 6:00 pm | **"Carbon Nation" - A Climate Change Solutions Movie** with Opening Remarks by Von Walden (Opera House) | | |
| 6:00 pm | **Dinner on your own** | | |

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| Continental |
| Limelight A |
| Limelight B |
| Limelight C |
| Limelight Promenade |

# 4th Annual NSF EPSCoR Western Consortium Tri-State Meeting

Sun Valley, ID

## WEDNESDAY, April 4, 2012

| | | | |
|---|---|---|---|
| 7:00 am - 12:00 pm | **Registration**<br>(Limelight Promenade) | | |
| 7:00 am - 8:00 am | **Breakfast Buffet**<br>(Limelight B) | | |
| 8:00 am - 9:45 am | **Plenary Session**<br>**Matt Germino**, US Geological Survey and **Ben Crosby**, Idaho State University<br>"The Changing Landscape of Science and Management of Land and Water: New Collaborative Initiatives and their Relevance"<br>(Limelight B) | | |
| 9:45 am - 10:15 am | **Networking Break**<br>(Limelight B) | | |
| 10:15 am - 12:00 pm | **Climate Education Resources**<br>Chair: Crystal Kolden (ID)<br>(Limelight A) | **Climate Change and Landscape Responses**<br>Chair: Jen Pierce (ID)<br>(Limelight B) | **Birds-of-a-Feather (BoF): Finding the Sweet Spot for Effective Academic-Agency Collaborations**<br>Chair: Tom Piechota (NV)<br>(Limelight C) |
| 12:00 pm - 1:30 pm | **Lunch - Keynote**<br>Jeanne Small, National Science Foundation<br>"Rotating Through EPSCoR"<br>(Limelight B) | | |
| 1:30 pm - 3:30 pm | **Infrastructure for Cyberlearning**<br>Chair: Lorie Liebrock (NM)<br>(Limelight A) | **Quantifying Ecosystem Services**<br>Chair: Lee Vierling (ID)<br>(Limelight B) | **Tri-State CI Resources for Data Sharing and Collaboration**<br>Chair: Karl Benedict (NM)<br>(Limelight C) |
| 3:30 pm - 3:45 pm | **Break** | | |
| 3:45 pm - 4:30 pm | **Nevada Breakout**<br>(Limelight A) | **Idaho Breakout**<br>(Limelight B) | **New Mexico Breakout**<br>(Limelight C) |
| 4:30 pm - 5:30 pm | **Poster Setup**<br>(Continental) | | |
| 5:30 pm - 7:30 pm | **Poster Session**<br>with Substantial Hors d'oeuvres and Dessert (provided as dinner)<br>(Continental) | | |


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| Continental |
| Limelight A |
| Limelight B |
| Limelight C |
| Limelight Promenade |

# 4th Annual NSF EPSCoR Western Consortium Tri-State Meeting

Sun Valley, ID

## THURSDAY, April 5, 2012

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|---|---|---|---|---|
| 7:00 am - 7:45 am | Breakfast Buffet (Limelight B) | | | |
| 7:45 am - 8:00 am | Announcement of Poster Competition Winners (Limelight B) | | | |
| 8:00 am - 9:45 pm | Hydrologic Information Systems Workshop (Limelight A) | Tri-State CI Working Group (Limelight B) | Tri-State Diversity Workshop (Limelight C) | Climate Modeling Tutorial (Continental) |
| 9:45 am - 10:15 am | Networking Break (Limelight B) | | | |
| 10:15 am - 12:00 pm | Hydrologic Information Systems Workshop (cont'd) (Limelight A) | Tri-State CI Working Group (cont'd) (Limelight B) | Tri-State Diversity Workshop (cont'd) (Limelight C) | Climate Modeling Tutorial (cont'd) (Continental) |
| 12:00pm - 1:30 pm | Lunch on your own | | | |
| 1:30 pm - 5:00 pm | C4D Death Valley Workshop (Limelight A) | Systems Modeling for Understanding Climate Change Workshop (Limelight B) | Tri-State Diversity Workshop (cont'd) (Limelight C) | Climate Modeling Tutorial (cont'd) (Continental) |

## Appendix B

## External Advisory Board Report and Responses

# Report of the NSF EPSCoR Tri-State Cyberinfrastructure Project (Track 2) External Advisory Committee (EAC)

**Year 3 Review**
Conducted February 23, 2012
Inn and Spa at Loretto, Santa Fe, New Mexico

## Introduction and General Findings/Recommendations

The External Advisory Committee (EAC) for the NSF EPSCoR Tri-State Cyberinfrastructure Project (Track 2) (TSCP) met on February 23, 2012 with project leaders and participants to review the effort. The meeting was held in the Inn and Spa at Loretto in Santa Fe, NM and was hosted by the New Mexico EPSCoR office. The EAC appreciates the opportunity to improve the project by providing feedback on its activities and directions. Through this report, the EAC offers its comments on, questions of, and recommendations to the Tri-State Cyberinfrastructure Project (Track 2). This summary begins with general findings, then addresses the three areas of the TSCP activity: (1) connectivity, (2) model and data interoperability, and (3) cyberlearning. TSCP personnel provided updates on each area in their EAC review meeting presentations. The presentations concluded with the plans to sustain project efforts after current EPSCoR funding ends in 2012.

The EAC first notes that the level of activity that the TSCP has stimulated to date is impressive. The three states, Idaho, Nevada, and New Mexico, have benefited greatly from the project, and the effort has been effective in leveraging Track 1 and other sources of funding. The project has excellent leadership and organization. As has been seen in previous years, the production of the review meeting and the presentations are clear evidence of this.

Immediately below are general recommendations of the EAC, applying across all three of the TSCP activity areas. The sections that follow address the focus areas individually.

1) Track 2 Final Year Wrap-Up

The TSCP is in the final year of its funded activities. It will be important for the project to bring its varied activities to clear conclusions with well-defined and tangible deliverables. Recommendations on how best to complete various project activities and deliverables will be provided in each of the three sections below. The EAC encourages the TSCP to consider another Track 2 application if and when the NSF again funds this initiative.

2) New External Evaluator

The EAC was impressed with the value added to the project by the change of the external evaluator, Lisa Kohne. The new measurement design and instruments have provided both structure and a formalized timescale for gathering important metrics that the project had been previously lacking. The new evaluator has clearly helped the TSCP leadership clarify desired project outcomes and put into place mechanisms for measuring progress toward them. The Track 2 EPSCoR Logic Model shows the goals, inputs, outputs, and outcomes of the project clearly

presented on a single page. We also note that the "Example Impacts Response" in Lisa's presentation, responds exactly to the committee's recommendations last year about gathering evidence of impact.

The four quarterly evaluation reports provided to the EAC are extensive and include well-defined data collection activities for all three areas of the project. Current and future evaluation plans and metrics are in place to track progress toward the completion of the project.

3) Intellectual Merit Results

The original Track 2 proposal made claims to develop a three-state cyberinfrastructure that would enable new collaborative research on climate. The proposal discussed linking atmosphere, surface, hydro, and socio-economic models into an integrated research platform. However, the committee questions whether this has been accomplished fully. It does recognize that the research results of the project are hard to quantify. Also, it is difficult to separate the research results in the related Track 1 and Track 2 projects. The committee presented research in progress towards these goals at the advisory board meeting (via graduate theses, etc.), and the group should include details about the various research projects in their final report.

The latest data on research publications and proposals are found in the June 2011 TSCP Year 2 Annual Report, which is not fully up-to-date for the EAC's current review. The EAC recommends that an effort be made to clearly report and justify the research contributions (intellectual merit) of the three-year TSCP Track 2 project.

> **Response:** We will pay particular attention to detailing the intellectual merit of the Track 2 project in the upcoming annual report to NSF.

4) Broader Impact Results

The EAC recognizes the significant efforts over the past year to demonstrate the impacts of the project to the broader communities of researchers, educators, and the general public. The new evaluation design focuses on both quantitative and qualitative data gathered from the users of the cyberinfrastructure, the modeling interfaces, and the educational programs. A side benefit of TSCP's efforts to collect data on impact is that it is encouraging the project clientele to think more broadly and take a longer-term view about their own aspirations.

In particular, survey instruments are being used to collect evidence on the impact of project activities. Additionally, qualitative data is being gathered in the form of quotations from program participants and success stories of use of the cyberinfrastructure platforms and educational programs. Current and future uses of outreach platforms, such as the videos being produced at UNLV, hold promise for sustaining the momentum of the project.

In the previous report, the EAC praised and encouraged the use of Innovation Working Groups (IWGs). During the past year, the project sponsored several successful IWGs. In particular, the EAC notes the Increasing the Diversity of the Western Tri-State Consortium IWG, which has led to a Tri-State diversity strategic plan and standing committee on diversity issues.

5) Awareness of Project Resources

The project has produced a significant set of resources for researchers, educators, and other potential users. The EAC believes that users should be made more aware of these resources and that use measures should be defined. One idea, for example, would be to develop a portal with Likert scale questions to have people enter data on usage. Some useful, but easy, open-ended questions can also be provided. The project PIs, for example, can send an email to all project members asking them to fill this questionnaire out 3–4 times per year. The resulting use statistics will demonstrate what resources are being used and by whom. These data would be very useful and could potentially seed other proposals. For example, say a particular visualization tool is being widely used: it might lead to a new proposal involving that tool. The project should keep track of new adopters, and possibly develop a login process for this. It would also be good to track use data on new adopters.

> **Response**: The evaluator has been working with the interoperability team members and developed a user survey, which is posted on the Nevada, New Mexico, and Idaho Data Portal webpages. Users are encouraged to complete this survey after they access Data Portal resources. Additionally, the data portals will be introduced to Tri-state Consortium participants. Data Portal developers will conduct a workshop in which participants use a data portal and complete the user survey. The evaluator will compile and analyze the results and report them to the data portal developers.

The EAC feels that that the involved universities should do some basic advertising to be sure research administrators, current faculty, new faculty, etc., know about the portals and what they offer. The TSCP universities really do have a vested interest in informing/reminding their faculty about this, pointing to capabilities that have been developed, thanks to NSF EPSCoR funding, to make the states more competitive.

> **Response**: The Tri-State CI Team will develop a coordinated plan to perform outreach within each of our respective states to better advertise the capabilities for data management, discovery, and access that have been developed under the auspices of the EPSCoR Track 1 and 2 programs. This plan will include both the content to be delivered, the methods of communication, and identified target communities for the information. A key component of this plan will be data portal training for potential users, including targeted training sessions throughout the remainder of the Track 2 project, also looking at opportunities for high-impact training through the end of the Track 1 project.

6) Sustainability of Track 2 Activities

TSCP leadership has, rightly, turned its focus to the long-term sustainability of the EPSCOR investment. The EAC believes that the project has a strong plan for sustaining its programs and cyberinfrastructure (CI) across the three states after the project winds down this year. Sustainability efforts are being planned for the TSCP areas of connectivity, model and data interoperability, and cyberlearning. On the aim of project sustainability, the EAC comments as follows:

- There is no doubt that the project has been successful in forging new collaborations in the three states. The EAC commends the TSCP for proactively addressing the challenge of

maintaining these partnerships and activities. The idea of charging individual groups (e.g., the interdisciplinary modeling course) to develop models for sustaining their own activities is particularly creative.

- One significant advance from the TSCP is a new transparency and coordination of state-level EPSCoR efforts. Examples are the development of the "academic/political landscapes" charts showing each state's organization of its activities, the plans to continue tri-state IWGs and diversity planning, and the development of a new, more coordinated approach on Track 1 proposals.

- It is a positive that NM opened slots in their Junior Faculty Leadership program to other states. In addition to enhancing the skillsets of junior faculty and helping them understand what is needed to build a successful research program, this creates new opportunities for developing inter-state collaborations.

- The annual Tri-State Meetings have become a notable success, with over 200 participants anticipated for the April 2012 meeting. The EAC believes that this meeting has momentum and will continue.

- It is promising that some of the Track 2 activities will be incorporated in Track 1 projects by the states.

- The potential of a collaborative Track 1 proposal is intriguing.

- Discussions with other Western states for future collaboration in areas of the areas of interoperability and cyberlearning are encouraged.

**Connectivity**

The TSCP has yielded substantial improvements in connectivity for all three states, varying in scale from individual sites to statewide. The TSCP team reported that all of the connectivity components have now been deployed. In the previous (Year 2) EAC report only two sites remained (Hagerman and Kimberly), and these have now been completed.

The EAC was pleased to see that the project's agenda was structured to frontload the connectivity deployments and that this is now complete and is serving the connectivity needs of the tri-state users. In some cases use has already exceeded former capacities. The focus of connectivity activities is centered on documenting the use and impact of improved connectivity in enhancing productivity. While it is easy to document use (i.e., "If you build it, they will come"), it is more challenging to quantify the long-term scientific outcomes. It is encouraging to see the team focusing on this, although the answers are not yet clear.

The Year 2 EAC report stated:

> "Now that the connectivity improvements are in place, the central task for physical CI is to establish its value to the tri-state STEM research enterprise. Doing so will require identifying metrics that clearly depict not only how the physical CI has improved research productivity, but especially, how it has given rise to new research capabilities and outcomes that were not possible before this deployment. For example, traditional network usage statistics are not particularly compelling as metrics for this project. Knowing aggregate data transfer rates before and after deployment is not necessarily a useful indicator of better science being enabled. The TSCP team should develop metrics that are more clearly related to the program goals of enabling research and of the integration of research into education."

The EAC applauds the accomplishments of the TSCP team with respect to collecting qualitative data in the form of specific use cases of the physical CI and the impact of the CI on those specific research and education endeavors. These use cases complement connectivity consumption data, which by itself is of limited value.

The EAC recommends pursuing additional forms of quantitative data to feature alongside the consumption and use case data. Possibilities are subnet analysis, measures of usage of specific connectivity-enabled capabilities (e.g., videoconferencing between specific sites), and impact headcounts (e.g., numbers of undergraduates, graduate students, postdocs, faculty, staff, K-12 teachers/students, etc., who have participated in the activities enabled by the physical CI).

> **Response:** The connectivity leads will meet with systems administrators to brainstorm ideas for pursuing additional forms of data. The evaluator will work with the connectivity lead to develop metrics and provide headcount data.

The project team should continue to clarify the broader impacts of the connectivity in all three states. The Year 2 EAC report stated:

> "A potentially useful approach would be for the team to request at least a few sites (e.g., the McCall site) to log the events where the CI was used for specific group activities, as opposed to general access to the Internet for individual use. The sites should be encouraged to provide testimonials of usage, such as: "We couldn't have gotten specialist X to participate in the workshop without the new CI capabilities.", or "This helped me carry out task Y, which previously I couldn't do." Do this longitudinally: for relevant STEM research and/or education teams, get near term responses at the event— What might you accomplish?— and then follow up a year or two later to see what they actually accomplished."

The accomplishments noted in the connectivity presentation were much in this spirit. The EAC was pleased to see this.

The Year 2 EAC report suggested:

> "At the TSCP annual meeting, conduct a CI usage survey to identify which groups and individual researchers are exploiting the CI, how they're exploiting it, and to what effect. To improve the response rate, withhold swag until they submit their completed survey."

The EAC did not see information on whether this had been done. The committee thus encourages the TSCP to use opportunities at upcoming meetings to gather survey information on CI usage and needs that may help identify worthwhile future CI capabilities to pursue.

> **Response:** The evaluator will work with the connectivity lead to develop this survey, which will be conducted at the Tri-state Consortium. The evaluator will include questions to assess additional cyberinfrastructure, connectivity, and interoperability needs.

The Year 2 EAC report also asked:

> "First, how sustainable is this effort? Will the infrastructure be supportable after the project with known funding or planned efforts to get sustaining funding? Second, is additional capability (e.g., bandwidth) already needed and/or anticipated?"

The EAC was pleased to see that the connectivity infrastructure seems to be on a sustainable path in that it has been assimilated into existing facilities. The committee reminds the TSCP to be aware, however, that network demand will increase. Thus, there is an ongoing need to look ahead to fill these needs and to gather data to support the requests to facilitate this.

**Model and Data Interoperability**

The EAC commends the TSCP on incorporating widespread standards for catalog services, metadata, data, map images, and web services. This not only facilitates current research and educational use of the data, but also gives the three states a strong foundation for smoothing transitions as new standards emerge (as one would expect a straightforward path from today's to tomorrow's standards).

> **Response:** The Tri-State interoperabilty plan continues to expand its plans to integrate appropriate interoperable protocols and standards into the published web services as appropriate. In addition to the highlighted OGC standards that have provided the interoperable core of the project, there are ongoing development efforts to develop or expand robust CUAHSI HIS services for some data being generated by the Tri-State consortium, and DataOne member nodes in ID and NM.

The ISO metadata standard is used to identify collections that might merit special treatment. The committee understands that the intent is to replicate metadata in the three states to improve search performance or, possibly, to mirror data in particularly high demand. The standard is also used to record and manage multiple versions of data. (In general, previous versions of a data object are maintained intact, in part to support reproducibility.) The idea of selective replication is a good one.

**Response:** Yes, the committee's understanding is correct. The intent is for full metadata replication between all three states, with the plan for data replication focusing on specific targeted data products that are identified by each state. When data are replicated between states, the developed ISO metadata model will allow for the maintenance of an authoritative metadata record that remains with the associated source data product, while the replicating states will host ISO metadata components that provide supplementary information about the replicas relating to replica contact information, available service, and download options. The master metadata record will include (by reference) the ISO metadata components hosted by the replicating states. With this model, a fully resolved metadata record may be generated based upon the master record and the linked components.

The committee understands the desire to develop graphical tools to couple models, but it questions the approach taken. One question concerns building yet another coupler when other, developed capabilities exist that have support groups and user bases. Coupling software capable of linking WRF to other models includes MCEL (Model Coupling Environmental Laboratory), MCT (Model Coupling Toolkit), and the ESMF (Earth System Modeling Framework). The committee questions why extant packages such as these have not been used. It seems a dubious use of limited NSF money to re-invent this software, which the public has, to varying extents, already paid for. If the "graphical" element is a distinction, why is that aspect critical? Have the user communities of WRF and the other candidate models been surveyed to determine the need for new coupling software, and if so, have user community requirements for this been gathered? If a new coupler is developed, how will the case be made to potential users that the framework is more efficient, or robust, or otherwise better than ones that have received substantial resources over many years?

A further question on the new capability is how it will be kept vibrant and up-to-date as the component models and computing environments (e.g., compilers, hardware) evolve. This encompasses, in part, a committee concern with how an effort based on the work of a student will be supported long-term. While the committee understands that it's important for CS grad students to do something new and different, that doesn't make it the best path in terms of the interests of the future user community or of the consumption of EPSCoR funds.

**Response:** Regarding the EAC's concern about re-inventing existing software for model coupling, our approach has been not to rewrite solutions already completed elsewhere but to extend them and provide new capabilities and features that they do not currently offer. Having examined the more prominent model coupling software systems, including MCT and ESMF, some of their limitations have been identified. In particular, most of these coupling systems are API-based, lack user interfaces to simplify user interaction, require writing code in specific programming languages, and have limited or no web-enabled development capabilities. In our approach we aim at providing software with user-friendly graphical interfaces and more flexible web-enabled data structuring and processing capabilities (while also allowing more advanced users to integrate their own scripts in their modeling and data processing scenarios). To some extent, our software is not a traditional model coupling framework, as it incorporates functions that can be used by scientists from various domains to perform data-related activities not necessarily pertaining to model coupling.

The graphical aspects of the user interface are indeed important to us. As indicated in the proposal submitted to NSF in 2009, we planned to design and implement software solutions focused on user-interface and human-computer interaction aspects. A major reason for this is that a graphical user interface significantly increases the number of users that can utilize a system over a command-line or code-based control system (mainly because less specialized computer knowledge is required) and, in general, can speed up the process of configuring and running a software application. Such interfaces reduce the learning time and help prevent and correct user errors. This, in turn, can increase the productivity of the users by allowing them to focus on the scientific aspects of their work rather than on coding.
To identify requirements for our software we have conferred with potential users and consulted partners from the Tri-State Western Consortium. The bulk of the requirements, however, have been developed by surveying the field of model coupling software frameworks and noting their strengths and weaknesses (and trying to address some of the latter). Certainly, we have taken notice of the EAC's specific comments on this point and will extend collecting requirements from the user community and incorporate them in our solutions. We have started a series of workshops focused on Tri-State data portals in which we will include demos of the newly developed software. Furthermore, we will include a user survey on our portal and will ask user community members to provide feedback on our work. Presentations at conferences will also be made to disseminate our results and elicit additional feedback.

We also have taken notice of the EAC's other remarks and we will demonstrate that the framework, which is also part of a PhD student's work, has additional or better capabilities than existing software systems. This will be done through comparisons with existing frameworks that will include feature-based evaluations and user testing and feedback.

To keep the software developed up-to-date we will document it properly and make it open source, allowing developers and users to contribute to it and improve it over the years. The software will also be deployed on the Nevada Climate Change Portal and made available to the community of users. Furthermore, we have communicated with CSDMS and plan to contribute our software to their repository.

The committee was a bit surprised that there is no requirement for the climate researchers funded under the TSCP to make their data available through the data portal. We encourage the TSCP leadership to "turn up the heat" on these groups to do so. It will look much better for them and the TSCP to show a clear connection: to show that a key aspect of the effort is really helping science. The committee also suggests including such requirements as part of future proposals.

**Response:** The direct data ingest model adopted by Nevada in developing their instrumentation transects has proven very effective in minimizing the delay in transferring obtained from those system. New Mexico and Idaho's current models of working with the researchers to integrate the data into the respective data portals is making slow, but measurable progress, and lessons learned from the current project will be captured and integrated into planning for the development of future data management and access CI.

**Cyberlearning**

As has been mentioned in the general comments of this report, the new evaluator has provided the project greater focus with regard to measuring perceived outcomes at university-level workshops, seminars, and conferences. Written instruments have made use of Likert scales that generally showed positive results in terms of the usefulness and effectiveness of the activities. The extended list of open-ended question responses was useful to provide additional information about the activities.

The pre-college activities continue to mature at different rates in the three states. The approach to evaluate the results of these projects was reasonably designed, focusing again on perceived effectiveness of the curricular materials and/or activities.

When the TSCP prepares its annual report, the EAC suggests that the following items be included or addressed:

- Gather data from workshop attendees with questions such as: "What has this allowed you to do that you could not do before? Be specific."

  **Response:** This question is already being included in all evaluation instruments.

- In the development of educational materials, describe how construct-centered design was used.

  **Response:** Construct-centered design was not explicitly used in the development of the educational materials. The development groups used a variety of pedagogical approaches. For example, NV C4D used a single pedagogical structure (5 DIE) as the foundation of their educational materials, which employed innovative uses of various technologies to highlight regional impacts of climate change. The 5-DIE format is inquiry-centered, rather than construct (or concept)-centered. In NM, GUTS is grounded in research on how simulations and computer modeling promote understanding of patterns and processes (key constructs) and develops higher order thinking and problem-solving skills. Similar to NV, GUTS has applied innovative technologies (agent-based modeling) to climate science. The MST teachers employ various approaches, based on their experience and understanding of pedagogical principles developed in their undergraduate work. The focus of the MST program is on developing science understanding, not developing specific pedagogical approaches or structures. In summary, we've been focused on addressing the Track 2 objective "to utilize cyberinfrastructure to integrate research with education to improve learning" without constriction of one pedagogical model. Furthermore, our group feels strongly the importance of continuing to follow the model that was designed as a way of thinking about science inquiry. It aligns with our goals and how instruction is delivered.

  With that said, there are many similarities between what we used and the construct-centered approach. As one example, the 5-DIE framework formalizes both the student experience as well as the teachers' development of materials. Although this approach is still under investigation, the framework has been developed as a result of an extensive review of the literature on scientific inquiry (Carroll, Crippen, Kern, & Ebert, in preparation). Further, curriculum development within 5-DIE is sequential and roughly

follows the steps outlined in the construct-centered approach. Overall, the materials are delivered from the following features:

Big Question:
1) Your initial ideas
2) Explore the evidence
3) Your scientific claims
4) The science related to the big question
5) Research council (share ideas)

For informational purposes, the evaluator provided the Cyberlearning lead with a short summary and design process of construct-centered design (http://assessment-ws.wikispaces.com/file/view/CCD_summary.pdf). The evaluator encourages all curriculum developers to identify and utilize a research-based design process that incorporates construct centered design methods.

- Make a list of the materials that have been developed, their target knowledge and skills, and their audiences (e.g., middle school, high school, undergraduate education, graduate education, or research resources, tools, etc.). In terms of usage, please gather precise data here and report it.

  **Response:** Creating a comprehensive list of developed materials with details specified above is an excellent idea and will be included in the final report.

- For *each* objective listed in the summary slide, be sure to address exactly what progress has been toward each objective (as it is a bit difficult to map some deliverables onto objectives).

  **Response**: This information will be provided in the final report. As clarification, as of February 2012, all objectives (Offer and support CI training in computation and climate change; Develop and disseminate educational materials for middle/high school; Develop and support extracurricular CI activities; Design/coordinate/advertise/deliver Industry CI Days Program) are nearly complete. For the remaining 6 months of the project, we are focusing on sustainability and cross-state collaborations for many of these activities.

**Summary**

The EAC commends the TSCP leaders and personnel on a good, productive effort to date. The project has continued to stimulate a great deal of activity, to generate capabilities, and to yield advancements for the partner states. All of this appears to make the three states more competitive, as per the overall EPSCoR goals. The EAC finds the broader impacts of the project to be significant in all three focus areas. The connectivity aims of the project have materialized, and will support elements of the other program areas. The data component has a solid foundation and tangible developments in the portals created to date, while the modeling component would benefit from a bit of clarification and from the actual realization of the proposed capabilities and consequent research. Cyberlearning is benefiting from the investment and, over the past year, the capacity to evaluate the impacts has been improved. The research (intellectual merit) achievements of the project should be more clearly presented and justified as the project nears a

conclusion. The EAC thanks the TSCP and EPSCoR for the opportunity to guide and improve the effort for the most efficient and productive use of NSF funds.

Prepared and Reviewed by the External Advisory Committee Members

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## Appendix C

## Highlights

## Students Supply Data to Research Community through National Hydrologic Database


**McCall Outdoor Science School Cyberlearning website connects students to the research community.**

Outcome:

A new website (http://mossi.tfhsbruins.com) allows teachers and students to integrate place-based citizen science with climate change education and research. It provides:

- Teaching tools that will broaden participation in, and understanding of, computational thinking and climate change science;
- Greater access for students to interactively use educational versions of climate models to test various climate change scenarios;
- Strengthened middle and high school extracurricular science education programs, allowing them to reach more teachers and students.

Impact/Benefits:

A new website supports teaching and learning about water resources in a changing climate for students and teachers across Idaho. Doing hands-on science in a local environment helps students relate science directly to their personal experience. This project expands Cyberinfrastructure (CI) awareness, increases use of CI, and better integrates quantitative reasoning, data analysis, and climate change modeling with education. This is one of the first examples of citizen science contributing to the database known as CUAHSI HIS (CUAHSI - Consortium of Universities for Advancement of Hydrologic Science, Inc. and HIS - Hydrologic Information System). It helps create a standardized way to store and share hydrologic data nationwide. By contributing to HIS, students learn the importance of data quality.

Explanation:

The McCall Outdoor Science School (MOSS) received funding from the Western Tri-State Consortium to create an internet-based, cyberlearning website to help students understand the impact of climate change on water resources in Idaho. This is done through internet-accessible curriculum and education materials developed for middle and high school students. Lesson plans are created for outdoor field settings to give students experience collecting water-related data. Students can upload data to a database through the website from wherever their school is located. Their ability to share data with peers and to contribute to a national database helps students understand the broader relevance of their work.

Highlight Provided by Sarah Penney, University of Idaho for EPS-0919514
Photo Provided by Karla Bradley, kbradley@uidaho.edu

## *Internet Connectivity Bolsters Access to Genetics Research from Remote Laboratory*

**Outcomes:**
A 100-fold increase in internet capacity allows data from state of the art population genetics studies to be shared readily between remote University research lab and the Columbia River Inter-Tribal Fish Commission. The required wireless towers also resulted in internet access that was previously unavailable to numerous rural Magic Valley businesses and families in Southern Idaho.

University of Idaho Hagerman Fish Culture Experiment Station, in Hagerman, Idaho

**Benefit:**
The Hagerman Research Station is now essentially on the University of Idaho campus internet network. Internet capacity jumped from 3 Mbps to 300 Mbps, a 100 fold increase in capacity and data transfer speed. The system now supports stable and real-time video conferencing as well as large data transfers associated with population genetics studies conducted with other universities and agencies. Data from new high-speed genetic sequencers can now be accessed and shared easily for research.

**Explanation:**
When the University of Idaho's Hagerman Fish Culture Experiment Station's was built in 2006 the only internet option was through phone connections with a maximum 3 Mbps of bandwidth. Slow internet connections essentially isolated the lab, and impeded communications and data sharing. Track 2 EPSCoR funding provided a wireless system that connects the remote research station to Boise where it links into the Idaho Regional Optical Network (IRON) for seamless connection within the University of Idaho secured network housed 460 miles away.

Highlight provided by Ron Hardy, University of Idaho for EPS-0919514
Photo provided by Ron Hardy, rhardy@uidaho.edu

# Cyberlearning Summit

*NSF Highlights – Track 2 & Collaboration*

### Title

1st Annual Tri-State Consortium Cyberlearning Summit

### Outcome

CL leaders efficiently collaborated on how the various approaches used by each program and their respective strengths could best be integrated and leveraged in STEM education and outreach. The summit also resulted in several cyberlearning sessions that were offered at the 4th Annual Tri-State meeting in Sun Valley, Idaho.

**Participants separated into teams to perform hands-on experiments with water quality instruments.**

### Impact/Benefits

CL leaders from each state contributed to a proposal to NSF's Cyberlearning: Transforming Education program that would support development of a research program. During the summit, it became clear that the programs developed individually were synergistic and would likely provide even more effective learning opportunities for students by incorporating components across projects.

## Explanation

A group of EPSCoR collaborators from New Mexico, Nevada, and Idaho joined together in Jemez Springs to discuss cyberlearning activities, programs, and materials that have been developed with support from the NSF EPSCoR Track 2 award. One component of the Western Tri-State Consortium (Track 2) of NV, NM and ID is the utilization of cyberinfrastructure to integrate research with education. Consequently, each of the states has developed cyberlearning (CL) tools related to the theme of water resources and climate change.

In January 2012, 26 participants from all three states convened in New Mexico to explore synergies that exist amongst the projects. During the two-day CL Summit, representatives of each state led demonstrations of the K-12 CL materials/programs that had been developed or expanded with NSF EPSCoR funding, including the McCall Outdoor Science School (MOSS) in Idaho, Growing up Thinking Scientifically (GUTS) in New Mexico, and implementation of Climate Change Cyberlearning Curriculum Development (C4D) in Nevada. In addition to learning about the programs, a goal of the summit was to identify components of the projects that were suitable for scaling up and dissemination to the other states.

Source: Natalie Willoughby, NM EPSCoR, University of New Mexico
Image provided by: Natalie Willoughby, nwilloughby@epscor.unm.edu