Preview of Award 1329470 - Annual Project Report

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1329470
Project Title:	Collaborative Research: The Western Consortium for Watershed Analysis, Visualization, and Exploration (WC-WAVE)
PD/PI Name:	William K Michener, Principal Investigator Karl K Benedict, Co-Principal Investigator Daniel Cadol, Co-Principal Investigator Mary Jo Daniel, Co-Principal Investigator Mark C Stone, Co-Principal Investigator
Recipient Organization:	University of New Mexico
Project/Grant Period:	08/01/2013 - 07/31/2016
Reporting Period:	08/01/2013 - 07/31/2014
Submitting Official (if other than PD\PI):	William K Michener Principal Investigator
Submission Date:	08/01/2014
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	William K Michener

Accomplishments

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

The states of Nevada, New Mexico, and Idaho have created the Western Consortium for Watershed Analysis, Visualization, and Exploration (WC-WAVE) whose overarching goal is to advance watershed science, workforce development and education with cyberinfrastructure (CI)-enabled discovery and innovation. WC-WAVE has four integrated teams: Watershed Science (WS), Visualization and Data CI (CI-Vis and CI-Data), and Workforce Development and Education (WFD). The three primary project goals and their respective contributions towards meeting the milestones for Year 1 are summarized below.

Watershed Science Component:
The goal of the WS team is to advance understanding of hydrologic interactions and their impact on ecosystem services using a virtual watershed (VW) framework. The WS and CI teams are creating a virtual watershed environment through model development process and integration. The resulting modeling tools will answer the proposed research questions and, in the process, establish a lasting and flexible watershed modeling framework to address new research questions that arise. Data from three watersheds are currently being gathered into a central data management infrastructure with an emphasis on the more ìdata readyî Reynolds Creek (ID), Dry Creek (ID) and Jemez (NM) watersheds first. In fulfillment of the Year 1 milestones the WS team has finalized which models will be employed for the project and individual faculty leads have been identified for each model. All WS consortium members have been working collaboratively to provide some of the empirical data from all watersheds to the CI teams and model assessment efforts will be completed by the end of Year 1. Education milestones for Year 1 included training on the CSDMS adapters for the models, which will take place during the May 28-31 Tri-State meeting, and the Snow Camp that was held during the March Tri-State meeting in Boise ID. Additional milestones that will be completed by the end of Year 1 include conceptual mapping of model inputs and outputs, identification of common boundary conditions and forcings for the models and definition of initial test cases based on study watersheds climatology. The WS Year 1 milestones are the key first steps towards achieving the overarching project goal to enhance watershed science through the development of VWs.

Cyberinfrastructure-Visualization Component:
The primary goal for the CI-Vis team, collaboratively with the CI-Data team, is to accelerate collaborative, interdisciplinary watershed research and discovery by creating innovative visualization environments and streamlined data management, discovery and access. The CI-Vis team is interconnecting real and synthetic data obtained through the CI-Data team from environmental sensing networks, computer-enabled processing and modeling activities pertaining to watershed research, and user-centered visualization techniques to create VWs and facilitate improved understanding of watershed dynamics. Three types of visualization environments that serve as interactive tools for the users of the proposed VWs are under development and include: desktop visualization environments for use on individual workstations; web-based visualization environments for use anywhere and anytime on a variety of devices, including mobile devices; and immersive visualization environments (such as stereoprojection or CAVE-based) for more sophisticated exploration and analysis of scientific 3D representations. During Year 1 the primary milestones of visualizations and a virtual realization of the Reynolds Creek watershed in ID achieved significant progress. A VWP for Reynolds Creek was created from existing LiDAR (light detection and ranging data of topography) and NAIP (National Agriculture Imagery Program) data resulting in a prototype that was demonstrated to all project participants. Refinement of this platform for all project watersheds and training project personnel in its use will meet the overarching goal to provide a visualization environment to advance watershed science.

Cyberinfrastructure-Data Component:
Within the overarching CI goal, the first two goals of the CI-Data team are to: (1) accelerate integrated watershed scale modeling through streamlined data access, transfer of outputs and associated metadata to data management systems, visualization, and model configuration; and 2) enable accelerated and broad access to research products, data and metadata through integration with national networks through interoperable data services. The data discovery component is critical because the addition of new models and other data products to the system will yield a continuously changing menu of available data products. The Virtual Watershed platform (VWP) provides the central access point for both data and documentation for use by the WS modeling activities and the data visualization system. The data and documentation added to the VWP will also be made available through external networks as appropriate for the specific data products. Specifically, point time-series data products will be made available through the CUAHSI (the Consortium of Universities for the Advancement of Hydrologic Science, Inc.) HIS (Hydrologic Information System), other data products will be made available through the DataONE (Data Observation Network for Earth) network, and any LiDAR products will be integrated

into the OpenTopography system. The third goal of the CI-Data team is to streamline data intensive research through improved data management skills. During Year 1 documentation will be produced to define data service requirements and interfaces. Other milestones that will be met by the end of Year 1 include: testing of the data delivery interfaces; CSDMS integration; data portal development; an operational data source platform; development of a test model adapter; integrate data management system with the CUAHSI HIS and DataOne; and training. Achievement of these milestones will provide the streamlined data access required to produce the primary project deliverable of a VWP that will enhance watershed science.

Workforce Development and Education Component:
The goal of the WFD team is to engage university faculty and graduate students in interdisciplinary, team research, and to broaden undergraduate student participation in STEM through modeling and visualization. The WFD goal will be met by providing Graduate Interdisciplinary Training (GIT) opportunities and creating an Undergraduate Visualization and Modeling Network (UVMN). All graduate students involved in the project, as well as their faculty advisors, will participate in an educational program that fosters interdisciplinary understanding and collaboration, modeled in part on the NSF Integrative Graduate Education and Research Traineeship (IGERT) program. Students will work in interdisciplinary groups on projects oriented around the WC-WAVE themes. In Year 1 the GIT milestone was achieved with a "Kick Off" Snow Camp for all graduate students and their advisors that provided a collaborative foundation for the project. The first of two cohorts of undergraduates and faculty for UVMN will have received training before the end of Year 1. Ultimately, the VW environments will provide a platform through which new technologies and research may be provided to undergraduates and faculty at predominantly undergraduate institutions (PUIs). Professional development for community college faculty, combined with improved STEM curriculum and resources, will improve watershed and computer science education in our states. Additionally STEM courses related to on-going research will increase student engagement and retention in STEM programs. Collectively, these project milestones will increase watershed and computer science knowledge within an interdisciplinary framework merging WS modeling with advanced data management and visualization.

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

Major Activities:

Goal 1, Watershed Science: Advance understanding of hydrologic interactions and their impact on ecosystem services using a VW framework.

The WS team has held regular monthly web-enabled meetings since the beginning of the project. Those meetings served to establish communication and file sharing systems, gave faculty time to review models and sites, and evaluate proposal goals and objectives. During the early months of the project students had not yet been recruited due to the timing of the grant funding cycle (too late for Fall recruitment of students). By the time of the March 2014 annual meeting in Boise ID, all students had been recruited so that the in-person meeting served as a kick-off event. At the meeting, we made significant progress on Milestones 1a, 1b, 1c, and 3. Milestones and accomplishments for each milestone are described below.

Goal 2, Visualization and Data CI: Accelerate collaborative, interdisciplinary watershed research and discovery through innovative visualization environments and through streamlined data management, discovery, and access.

Major activities for the CI-Vis team during Year 1 included the following:
* Identification of initial design requirements for adapters between the Visualization Environment and Virtual Watershed [Objective 1] (between the

CI-Vis and CI-Data groups).
* Development of a distributed immersive visualization library to be used by the immersive front end [Objective 2].
* Development of a desktop visualization front end and a Web based visualization front end [Objective 2] (Figure 2, Figure 3, and Figure 4 ñ in Accomplishments) as well as an augmented reality sandbox [Objective 2] (Figure 1 in Accomplishments).
* Hiring and mentoring of students to work on the project [Objective 4].
* Papers submitted and presentations given [Objective 5].
The Year 1 activities of the CI-Data component fall into three categories: streamlined data access, upload, discovery and documentation technologies for watershed-scale modeling and visualization; accelerated integration into and enhanced access to OpenTopography, CUAHSI, and DataONE services; and the provision of data management training to EPSCoR researchers and their students. These activities have included the following:
* Coordination with the other project components to determine the requirements for the Virtual Watershed platform (VWP) and associated adapters that link the VWP to the planned Watershed Science (WS) models and visualization capabilities. By the end of Year 1 this coordination will produce documentation that defines the service requirements and interfaces between the visualization system, the VWP and the model execution environment(s).
* Identification of the data requirements for both the WS modeling activities and the CI-Vis component. This activity has already produced an increasingly specific list of data requirements and products for each of the planned WS models, with those requirements driving the identification of data sources and strategies for integration of those data into the VWP, resulting in a requirements document in Year 1.
* Deployment of the initial VWP. Based upon the core capabilities provided by the Geographic Storage, Transformation and Retrieval Engine platform (GSToRE). GSToRE is an integrated data management, discovery, and publication platform developed by the Earth Data Analysis Center (EDAC) with support from the NSF EPSCoR program (among others), A WC-WAVE specific instance of the initial VWP will be deployed in New Mexico (NM), with modifications to streamline the deployment of partner platforms in Idaho (ID) and Nevada (NV) in subsequent project years.
* VWP Adapter Development. Documenting data requirements and data products (described as manual integration in the proposal) and the sharing of sample source and product data through a shared data sharing platform as a reference for parallel development will be completed by the end of Year 1.
* Integration with National Networks. ID and NM will have operational DataONE (Tier 1 for NM, Tier 4 for ID) and CUAHSI services by the end of Year 1.
* Data management training. An initial data management training module has been developed and delivered to a mixed audience of EPSCoR Track 2 and Track 1 graduate students and other graduate students in conjunction with a half-day responsible conduct of research course.

Goal 3, Workforce Development and education, Engage university faculty and graduate students in interdisciplinary team-based watershed research, and broaden undergraduate student participation in STEM through modeling and visualization.

The WFD Team is targeting two groups within the single goal for this component: Objective 1) graduate students working in the WC-WAVE Watershed Science and CI components, and Objective 2) students and faculty at primarily undergraduate institutions (PUI) in the three Consortium States.
Objective 1 Activities: In March 2014, we held a three-day "Kick Off" Snow Camp for project students and faculty as part of the projectís winter Tri-State Meeting held in Boise, ID. Nine faculty members (2 NM, 4 ID, 3 NV) and 15 students (7 NM, 5 ID, 3 NV) participated. The camp agenda began with an introduction to snow hydrology field measurement techniques and an overview of the Dry Creek study area, which served as the basis for a field exercise in which students and faculty collected data and discussed initial analyses. Participants stayed on-site and prepared meals together as part of an informal networking endeavor that was a vital aspect of initiating sustainable collaborations. Snow Camp participants then joined other Consortium participants at the Winter Tri-State Meeting, which provided an opportunity for the students to understand the overarching goals and objectives of the WC-WAVE project and the role they play in the Consortium's research. The WFD Team led a session in which students and faculty provided input on their training and education needs that the WFD Team will now use to develop agendas for future Consortium meetings. The WFD Team is also collaborating with members of the WS and CI-Data teams to develop the first Graduate Interdisciplinary Training summer institute, which will be held May 28-31, 2014 in Albuquerque, NM; it will focus on training in using CSDMS (Community Surface Dynamics Modeling System).

Objective 2 Activities: The WFD Team has completed preparations needed to launch the Undergraduate Visualization and Modeling Network (UVMN). The UVMN begins with a summer workshop for teams of instructors and students from Consortium PUIs. The WFD Team has identified the workshop content, developed application materials, and recruited and selected applicants for the first cohort. Eleven teamsóone faculty member and one student from the same institutionóhave been selected: 6 from NM, 3 from NV, and 2 from ID. They represent 7 community colleges, 2 tribal colleges, 1 regional university, and 1 two-year branch campus. The initial three-day workshop will be held in Albuquerque, NM and is scheduled for May 29-31, 2014, coinciding with the summer Graduate Interdisciplinary Training session described above. An evening reception and dinner will initiate connections and communication between the two groups.

Specific Objectives: Goal 1, Watershed Sciences
Within this goal, there are three research objectives. Objective four is education-related and is shared by the WS and WFD components (see WFD Objective 1 below). Each objective crosses all three project years.
1. Parameterize and validate watershed models.
2. Develop CSDMS adapters for models.
3. Test VW applications and answer research questions using the VW platforms to investigate watershed ecosystem services.
4. Snow camp and summer institutes (shared with WFD)

Goal 2, Visualization and Data CI

CI-Vis objectives include:
1. Develop and deploy visualization environment.
2. Develop user interfaces.
3. Train users on how to use the visualization environment.
4. Educate graduate students on CI for watershed research.
5. Disseminate results.
CI-Data Goal 1: Accelerate integrated watershed scale modeling through streamlined data access, transfer of outputs and associated metadata to data management systems, visualization, model configuration. The objectives for this specific CI-Data goal are:
1a. Define data required by models and visualization tools.
1b. Define model and visualization tool data format requirements.
1c. Define model configuration options to be exposed through the VW and visualization tool.
2. Define model integration workflow.
3. Deploy virtual watershed data and service platform.
4. Deploy data source to Virtual Watershed Platform adapters.
5. Deploy virtual watershed model adapters.
6. Deploy virtual watershed to Visualization Environment adapter.

CI-Data Goal 2: Enable accelerated and broad access to research products, data and metadata through integration with national networks through interoperable data services. The objectives for this specific CI-Data goal are:
1. Integrate data management system with CUAHSI HIS WaterOneFlow service network
2. Integrate data management system with DataOne network as Tier 4 member nodes.

CI-Data Goal 3: Streamline data intensive research through improved data management skills. The objective for this specific CI-Data goal are:
1. Provide annual data management workshops for EPSCoR researchers and their students

Goal 3, Workforce Development and Education
The Year 1 objectives are:
1. Develop a Graduate Interdisciplinary Training (GIT) Program
a. Snow Camp
b. Summer Interdisciplinary Training
c. Tri-State Meetings additional training
2. Develop an Undergraduate Visualization and Modeling Network (UVMN).

Significant Results: Goal 1, Watershed Science
Objective 1, Milestone 1a: Review and finalize models to be used. Upon review of the proposed models we have decided to tailor modeling activities to specific watersheds that improves upon our initial concept of applying all models to all sites. We are retaining the task of applying the snow accumulation and melt model iSNOBAL to all sites. Watershed and riparian zone models, however, are being selected based on how well the model suits a specific site. Currently, we are including seven models in the Virtual Watershed suite of models, as opposed to the four models in the original proposal. We have initiated discussions with the CI-Vis and CI-data teams to develop a strategy for

incorporating multiple models into the VW platform.

Objective 1, Milestone 1b: Conceptually map model outputs and inputs for watersheds. We created a spreadsheet in a shared Dropbox folder in which modelers are providing inputs, outputs, and other model information to serve as a learning tool for students, as well as to communicate visualization and data needs to CI teams.

Objective 1, Milestone 1c: Identify required forcings and boundary conditions, particularly those common to different models. We are moving this milestone to the second project year. The milestone is best met after students learn how to implement the models.
Objective 2, Milestone 1: Participate in training at summer institute with CI to learn developing adapters that are specific to particular models. Dr. Scott Peckham delivered an online seminar for our group to introduce CSDMS. A graduate training institute specifically designed for students (and faculty) to learn and implement CSDMS is planned for May 2014.

Objective 3, Milestone 1: Define initial test cases based on climatology of study watersheds. The January meeting facilitated essential discussions between CI and WS participants. WS participants had the opportunity to explain to CI teams what visualization and data capabilities we would like to see in the VW platform, while CI participants explained to WS participants what is possible. A key outcome was a decision to focus on a sample dataset from one watershed (Milestone 3). With this sample dataset, WS participants can clearly illustrate data sources and data types, and the CI team can produce example visualizations and database structures. The sample dataset is a published dataset from the Dry Creek Experimental Watershed (ID) containing all data necessary to run the iSNOBAL model. Model outputs are included in a second paper that is in final revision. With this dataset, the CI team will have a complete product from data source to model output that will be used to generate example VW products. Once complete, the CI and WS teams will discuss the examples and decide how to move forward with other project watersheds.

Objective 3, Milestone 2: Develop synthetic datasets as appropriate. Because the focus in Year 1 was on the calibration of models using empirical data, this milestone will be completed in Year 2.

Goal 2, Visualization and Data CI
Objective 1 (CI-Vis): Design of VE-VWs adapters has begun with input from WS group on CSDMS adapters and integration. Implementation of these adapters will continue.

Objective 2 (CI-Vis): A rapid prototype of the desktop and web based VWP was demonstrated at the March 2014 Tri-State meeting in Boise ID. Initial visualization demonstrations have resulted in the WS team requesting several additional items for visualization that could provide a positive impact on their research and teaching.

Objective 3 (CI-Vis): No planned activities for Year 1.

Objective 4 (CI-Vis): We have hired graduate and undergraduate students at most institutions. Hiring was delayed due to the start of the award being so close to the start of the school year but should be completed this summer.

Objective 5 (CI-Vis): We have submitted a few papers and have begun work on proposals.

Goal 1, Objectives 1a and 1b (CI-Data): Testing the use of OGC WCS (Open Geospatial Consortium web coverage service) published by EDACís GSToRE as a model for data delivery into the visualization system has started. This testing will identify opportunities and challenges for the delivery and use of data hosted by the VWP, providing experience by the end of Year 1 with the pros and cons of on-demand data access versus local storage and caching of data by the visualization system.

Goal1, Objectives 1 and 2 (CI-Data): Questions about the specifics of the CSDMS integration model for the WS models used in the project have delayed the planning for specific model adapters due to the fundamentally different integration strategies that would be used for CSDMS vs non-CSDMS implementations. The CSDMS specifics will be resolved by early in Year 2.

Goal 1, Objectives 3 and 4 (CI-Data): Data portal development has continued: Nevadaís ìNevada Climate Change Portalî is being transformed to the ìNevada Research Data Centerî (funded by NVís Track 1 project), with increased storage and processing capacity; Idahoís ìNorthwest Knowledge Networkî (NKN) Scientific Data Repository has added 450TB of storage and increased network capacity (with support from an NSF Cyberinfrastructure Improvement Grant); and, New Mexicoís EPSCoR data portal has expanded with additional storage (150TB, funded by EPSCoR Track 1 and 2 projects), a new OpenStack cloud computing platform, and expansion of the Gstore data/metadata capabilities and search services.

Goal 2 (CI-Data): New Mexicoís Tier 1 DataONE Member Node (MN) will be operational by the end of project Year 1. Idaho is testing its Tier 4 DataONE MN, well ahead of the planned year 2 development and year 3 deployment targets. CUAHSI integration continues in all three states: ID has operational CUAHSI HydroServer instances, EDAC in NM has a partial implementation of the CUAHSI WaterOneFlow API within Gstore, and expects to have a CUAHSI instance running late in project year 1 or early in project year 2. Nevada is currently developing CUAHSI capabilities on top of their data management system.

Goals 1-3 (CI-Data): All three states have expanded their faculty, students and staff capacity. Nevadaís team includes two faculty, three graduate and one undergraduate students; NM has one faculty, two staff (part-time on WC-WAVE) and three students (split between EPSCoR Track 1 and 2 projects), with a planned third staff position; ID currently has one regular staff, a planned

software developer and one doctoral student working on related NKN projects (externally funded).

Goal 3, Workforce Development and Education
Because the WFD team is not conducting research, their results are reported under the Impacts section below.

Key outcomes or Other achievements:

The work in all three states has been enhanced by the prior investments made by NSFís EPSCoR program through our previous Track 1 and Track 2 projects ñ specifically in the area of the data portals and underlying cyberinfrastructure that were developed by those projects. This leveraging of investments continues with the strong overlap in the underlying infrastructure that is being developed and used in all three states in support of the new EPSCoR Track 1 awards that each state has in addition to the funds provided through the WC-WAVE project. Also, the CSDMS integration model for both VWP data services and the WS models will make use of the computational and model interoperability capacity provided by this NSF-funded center.

Idaho has leveraged the increased network capacity provided by an NSF Cyberinfrastructure Improvement Grant as a core capability that is increasing the capacity of the Idaho WC-WAVE team to interact and exchange data. Additionally, the NKN was partially supported by previous NSF EPSCoR investments and the current work on NKN builds upon those previous investments.

New Mexico has contributed to a collaborative NSF EarthCube Building Blocks proposal that focuses on cloud computing in support of geosciences, which, if funded may provide additional models for more efficient model execution in support of the watershed science work funded by the WC-WAVE project. Additionally EDAC is an unfunded collaborator on a submitted NSF DIBBs (Data Infrastructure Building Blocks) proposal that focuses on metadata evaluation and improvement, the results of which are anticipated to contribute to the ongoing improvement in the documentation for EPSCoR-generated data products. New Mexico is continuing the expansion of the capabilities of the GSToRE data management platform developed during the previous EPSCoR projects in support of both the WC-WAVE VWP, New Mexicoís Track 1 EPSCoR Data Portal, and other NSF and non-NSF funded research projects.

Nevada is continuing to build upon past and current NSF funded research platforms and products through the ongoing development of the Nevada Research Data Center, which is based upon the previously produced Nevada Climate Change Portal, and leveraging ongoing development of their CUAHSI integration capabilities through their linkages with the CUAHSI program (Dr. Scott Tyler, CUAHSI Board Director and member of WS team).

Goal 1 Watershed Science: 58% of Year 1 milestones have been met for this goal as of the date that this report was prepared (60% into Year 1).

Objective 1: Parameterize and validate watershed models.
Milestone 1: Conduct a first-year project meeting, 100% complete. Models were reviewed and seven selected for development. Model outputs and

watershed inputs were conceptually mapped and shared with CI. Required forcings and boundary conditions were identified, particularly those common to different models. We expect to have each model calibrated in test watersheds by August 2014.

Objective 2: Develop CSDMS adapters for models, 20% complete. A presentation was provided to the WS team by CSDMS lead developer, Scott Peckham. The summer institute, which will take in NM in May 2014, will provide CSDSM training by Scott Peckham to WS and CI faculty and graduate students with the primary goal of learning how to develop adapters that are specific to particular models.

Objective 3: Test VW applications and answer research questions using the VW platforms to investigate watershed ecosystem services, 10% complete. The initial test cases have been defined based on climatology of study watersheds. Synthetic datasets will be developed in year 2.

Objective 4: Snow camp and summer institutes (part of WFD objectives and discussed in more detail within WFD results), 100% complete.

Goal 2, Visualization and Data CI: collectively 53% of the Year 1 activities have been completed at the time of this report preparation (60% into Year 1).

CI-Vis Objectives:
Objective 1: Develop and deploy Visualization Environment Virtual Watershed Platform adapters.
Development was started in Year 1 and will be completed in Year 2 ñ 25% completed.
Objective 2: Develop user interfaces (ìfront end interfacesî) for the visualization environments
Define functional and non-functional requirements for front ends ñ 80% complete.
Create rapid prototype of (desktop 100%, web, 100%, immersive, 50% complete).
Objective 3: Train users how to use the visualization environments.
No deliverables in Year 1.
Objective 4: Educate graduate students on CI for watershed research.
Hire undergraduate and graduate students and advise ñ 100 % complete.
Objective 5: Disseminate results.
Submit papers and deliver presentations ñ 100% complete.
Several members of the CI-VIS group were involved in an NSF Science and Technology Center meeting on Forest Fire Visualization that was held at the University of Idaho ñ April 2014.

CI-Data Goal 1 Objectives:
Objective 1a: Define data required by models and visualization tools, 60% complete.
Objective 1b: Define model and visualization too data format requirements, 60% complete.
Objective 1c: Define model configuration options to be exposed through the

virtual watershed and visualization tool, 20% complete.
Objective 2: Define model integration workflow, 10% complete.
Objective 3: Deploy virtual watershed data and service platform, 100% complete.
Objective 4: Deploy data source to Virtual Watershed adapters, 70% complete.
Objective 5: Deploy virtual watershed model adapters, 10% complete.
Objective 6: Deploy virtual watershed to Visualization Environment adapter; no task milestones for Year 1, but ahead of schedule in testing of OGC WCS as an adapter interface.

CI-Data Goal 2 Objectives:
Objective 1: Integrate data management system with CUAHSI HIS WaterOneFlow service network, 90% complete.
Objective 2: Integrate data management system with DataOne network as Tier 4 member nodes, 50% complete (NM), ID ahead of schedule with testing of Tier 4 MN in year 1.

CI-Data Goal 3 Objectives:
Objective 1: Provide annual data management workshops for EPSCoR researchers and their students, 33% complete (provided to NM Students scheduling for Tri-state meeting).

Goal 3, Workforce Development and Education: as of the time that this report was prepared 85% of the year 1 activities have been completed (60% into the year).
Year 1 Objectives with target dates and percentage of completion:
Objective 1: Develop a Graduate Interdisciplinary Training (GIT) Program.
a. Snow Camp, winter 2014 - 100% complete March 2014.
b. Summer Interdisciplinary Training, summer 2014 planning 75% complete; implementation will be completed by end of Year 1.
c. Tri-State Meetings additional training, ongoing 100% on schedule.
Objective 2: Develop an Undergraduate Visualization and Modeling Network (UVMN).
a. Participant application and selection, spring 2014 100% complete March 2014.
b. First workshop, summer 2014 planning 75% complete; workshop will be implemented in May 2014, before the end of Year 1.

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

Broadening Participation

In Year 1 of the project there were 100 participants from the three partner states. Of those, 42% were female and 10% were from underrepresented minority groups. Four disabled participants, or 4%, were also a part of the project. Out of 15 individuals comprising the Leadership Team 33% were female.

Of the 20 graduate students working on the project 45% were female, and 20% underrepresented minorities. Eighteen undergraduates were involved in the project, with 38% female, 5% underrepresented minority, and 5% disabled. The membership of the WC-WAVE External Advisory Board, including the external evaluators, equaled 8 individuals. Of those 50% were female.

Goal 1, Watershed Science:
The Watershed Science team was involved in the planning and implementation of Snow Camp and according to participant comments and survey results, this effort was quite successful both from a scientific training and a team building point of view. The activities of Snow Camp are reported in more detail in the WFD sections. During the next reporting period graduate students will learn detailed information about the models and watershed sites. Monthly web-based meetings will feature presentations by graduate students about model progress.

Goal 2, Visualization and Data CI:
The seven graduate students supported by the WC-WAVE project as part of the CI-Data activities are all supervised by faculty or professional staff who are experts in their respective fields of computer science (Nevada), and data management and information architecture development (Idaho and New Mexico). In the context of the project, they are actively participating in the development of technologies and information resources related to the project, which in some cases are also directly related to their degree programs (i.e. their thesis or dissertation topics). Additionally, Nevada also has an undergraduate student that is participating in their program. Project participation is contributing to the knowledge of that student in the context of the real-world data assimilation, management and delivery problems posed by the CI-Data activities.

Additionally, Dr. Benedict (New Mexico) has developed and delivered a 90-minute Data Management Primer for researchers and their students that has now been delivered to a mixed audience of EPSCoR funded and non-EPSCoR funded graduate students in conjunction with the NSF required ìResponsible Conduct of Researchî course recently presented at New Mexico Tech. This course will provide the foundation for ongoing data management training that is an overall goal of the CI-Data component.

Goal 3, Workforce Development and Education:
Twenty-six project personnel participated in Snow Camp in March 2014 during which they learned snow hydrology and measurement methods. They also built a collaborative foundation for ongoing interdisciplinary team-based research. During the Winter Tri-State Meeting that immediately followed Snow Camp, all members of the Consortium learned about modeling and visualization techniques as well as advances in environmental data and analysis employed by Google Earth Engine. A post-event website was created by ID EPSCoR which includes presentations and photos of the field events and meeting (http://app.certain.com/profile /web/index.cfm?PKwebID=0x607032f60c&varPage=home). By the end of Year 1, graduate students and faculty will have participated in a workshop that will prepare them to use CSDMS for ongoing WC-WAVE research.

By the end of Year 1, the first cohort of UVMN participants will have completed the initial workshop that will focus on using Google Earth to create GIS content, developed a watershed model and use the model to visualize various scenarios, used free geographical data sources and software, and employed novel approaches to create 3D models. A team of faculty from Consortium research institutions, one from each state, is leading the workshop.

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

Overall project outreach during Year 1 has varied by component with limited outreach thus far by the WS team. The WS team anticipates broadening their research result dissemination as graduate student research activities are initiated and results start to come in.

The CI-VIS group has attended several meetings to demonstrate the work they have been doing. These have included several outreach events on the various campuses, demonstrations in several courses, and presentations to several community gatherings off campus, as listed below by institution (ISU is Idaho State University, UI is University of Idaho and UNR is University of Nevada Reno).
ISU: GIS Day Nov 2013 Demonstration of the Virtual Sandbox.
ISU: GEOL 210 Nov 2013 ñ Interactive Lab demonstration of Virtual Sandbox.

ISU: Idaho Science and Engineering Festival April 2014 Demonstration of Virtual Sandbox.
ISU: Geoscience Open House Mar 2014 ñ Demonstration of the Virtual Sandbox.
ISU: Student Organization Fair Feb 2014 ñ Demonstration of the Virtual Sandbox.
UI: North Idaho GIS user group Nov 2013 ñ Virtualized landscapes presentation. Couer d'Alene, ID.
UI: Keynote Presentation Oct 2013 ñ "The Virtual Universe", incorporating virtualized landscapes for community design; Lopez Land Trust annual Farm to Table Event. Lopez Island, Washington.
UNR: Visualization Keynote: April 2014 - Fire Science Workshop, Moscow ID.
UNR: Senior Projects Presentation: May 2014 Demonstration of Desktop interface.

Content has been populated into the three state data portals by the CI-Data team, whether in the form of new data, links to resources or events, or other content. These materials are broadly available to any visitors to the project data portals. Improvements were made to the HTML metadata representations available for the data holdings in GSToRE (and by extension the VWP, as the VWP is based upon the GSToRE code base). This effort includes schema.org elements for improved discovery of data through standard search engines such as Google, which is an ongoing activity for ìsearch engine optimizationî to increase the discoverability of the project research data products.

As part of the WFD team's effort to recruit participants for the UVMN, Education, Outreach and Diversity (EOD) Coordinators from each state distributed project information electronically and visited PUI institutions in their state. They used these opportunities to discuss WC-WAVE research and education activities. In New Mexico, the EOD Coordinator traveled over 1300 miles to visit six campuses; see http://nmepscor.org/blog/by-the-numbers. NM also held a webinar to discuss the UVMN project with potential applicants. Nevada emailed the UVMN announcement 4 times to their listserv, posted the opportunity on Facebook and traveled to 3 of the 4 PUI campuses in Nevada. The NV EOD Coordinator provided a 2 hour workshop on undergraduate opportunities available through NV EPSCoR, including the UVMN. Idaho used their network of Track 1 MILES Ambassadors -contacts at PUIs- to disseminate project information to campuses around the state. The Ambassadors sent the information to various departments and list-serves to recruit for participants as well as visited various courses related to UVMN to identify potential faculty/students.

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

The next phase of developing the Virtual Watershed Framework (VWF) for achieving the project’s goal of advancing understanding of hydrologic interactions and their impacts on ecosystem services will involve three main tasks. The first will be for each student and advisor research team to parameterize and validate the watershed models for the test watersheds. An essential aspect of this activity will be to collaborate with the CI team to perform initial one-way or “loose” coupling of the models. The second task will be to develop robust CSDMS (Community Surface Dynamics Modeling System) adaptors for the models in collaboration with the CI team. Adaptor development will be facilitated by knowledge gained at the CSDMS training at the May 2014 Tri-State meeting in New Mexico. Initial test adapters for select models will be developed by August 2014. The third planned task will be to train graduate students on using the models and adaptors at the 2015 Summer Institute workshop.

To meet the goal of developing a visualization environment to advance watershed science, the CI visualization team has several plans in the coming year. The first is to complete the design and implementation of adapters between visualization interfaces and the virtual watershed framework. This will be done in collaboration with the CI-Data team. An alpha desktop visualization front end, which will be web based and alpha immersive, will be completed and demonstrated to the watershed science team for feedback. Demonstrations and training of the desktop visualization front end will be an integral part of the 2015 Winter Tri-State meeting.

Development and evolution of data discovery and access services, as well as model integration workflow by the CI-Data team, will continue in Year 2. The watershed and CI teams rely on these services to execute models and

visualize results. Client adapters to OpenTopography, CUAHSI, and DataONE will be deployed, enabling the discovery of data products that are available from each of these external networks, with data integration from CUAHSI and OpenTopography enabled through implementing the Application Programming Interfaces. Orchestration of data access and delivery into the VWF are planned through predefined configuration files that specify the behavior of the data-model adapters and facilitate data output integration back into the VWF. Model and visualization adapter development will continue, resulting in the deployment of at least one model adapter and one visualization adapter. Integration of project data products into national networks will continue, with CUAHSI support for all three states and deployment of DataONE Tier 4 member nodes in ID and NM. As the capabilities of the VWF are developed, and model and visualization system integration moves forward, annual data management training workshops will be augmented with training in the specific capabilities developed by the project in support of watershed science and visualization.

In the coming year, the Workforce Development Team will continue efforts to engage faculty and graduate students in interdisciplinary team research, and to broaden undergraduate student participation in STEM through modeling and visualization. The team will help shape the agendas of the virtual Tri-State Coordination meetings and face-to-face Tri-State Meetings to address training needs identified by Consortium participants. We will also offer the 2015 Summer Institute for graduate students, which will be an Interdisciplinary Modeling Course. The Undergraduate Visualization and Modeling Network (UVMN) participants will be supported and mentored to implement the content they learned in the Year 1 workshop in their undergraduate courses. They will be invited to share the results of their work at upcoming Tri-State Meetings, which will give them the opportunity to learn more about the Consortium's research at the same time. A second UVMN cohort will be selected and a workshop offered during Year 2, using input from the external evaluation to enhance and improve the activities.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
CI-Visualization_Figures.pdf	Examples of CI-Visualization Team's work referenced in the Accomplishments section.	William Michener	04/30/2014

Products

Books

Book Chapters

Conference Papers and Presentations

Del Rio, Nicholas, Natalia Villanueva-Rosales, Deana Pennington, Karl Benedict, Aimee Stewart, C. J. Grady (2013). *ELSEWeb Meets SADI: Supporting Data-to-Model Integration for Biodiversity Forecasting'*. Association for the Advancement of Artificial Intelligence Fall Symposium. Arlington, VA. Status = OTHER; Acknowledgement of Federal Support = No

Robinson, Erin, Carol B. Meyer, Karl Kent Benedict (2013). *ESIP Federation: A Case Study on Enabling Collaboration Infrastructure to Support Earth Science Informatics Communities'*. AGU Fall meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = No

Karl Benedict (2013). *Invited Panelist for 'Connecting Data Stakeholders for a Long-term Vision of Data Stewardship' Town Hall Meeting*. AGU Fall meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Del Rio, Nicholas, Deana D. Pennington, Karl Kent Benedict, Natalia Villanueva-Rosales, William B. Hudspeth, Soren Scott, Aimee M. Stewart, Cj Grady (2013). *Leveraging Industry-Standard Metadata to Populate a Semantic Registry Suitable for the Model Web'*. AGU Fall meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = No

Benedict, Karl Kent, Soren Scott (2013). *Pragmatic Metadata Management for Integration into Multiple Spatial Data Infrastructure Systems and Platforms'*. AGU Fall meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Yu. Manzhu, Karl Kent Benedict, Qunying Huang, Zhipeng Gui, Jizhe Xia, Songqing Chen (2013). *Validating Dust Storm Model Using Satellite Aerosol Retrievals and Ground-based Observations'*. AGU Fall meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = No

Inventions

Journals

Licenses

Other Products

Other Publications

Patents

Technologies or Techniques

Acquired additional storage capacity in support of local caching of data products hosted by Gstore (see above)

Acquisition, testing and deployment of a pilot-scale OpenStack cloud computing platform for use in support of EPSCoR development efforts. This platform currently consists of 4 nodes, with two more that have been ordered in support of fail-over capacity for hosted machine instances. (jointly funded through EPSCoR Track 1 and Track 2 funds)

Continued development of the Gstore data management platform upon which the proposed Virtual Watershed platform is based. This has included expansion of the supported metadata standards to now include the use of the ISO 19115-2 Data Series metadata model for embedding dataset provenance information into metadata, improvements in the system's ability to export Dublin Core metadata as an alternative representation of data documentation, and integration of an ElasticSearch-based indexing and search platform into the supported data discovery services provided by Gstore. Support for non-geospatial tabular data into the system has also been added to Gstore as a core data model upon which value added services may be built. Additional Gstore deployment models have also been under development to enable streamlined transitioning from development to operations and also more efficient deployment of virtual watershed platform system into the partner EPSCoR jurisdictions in year 2. (jointly funded through EPSCoR Track 1 and Track 2)

Deployed an instance of the OwnCloud hosted file sharing and cloud storage platform in support of data-focused collaboration for both the EPSCoR Track 2 and Track 1

Thesis/Dissertations

Websites
NM EPSCoR Data Management Content Area
http://nmepscor.org/data_portal/data-management-document-training

Contributed content to this area where resources related to data management are collected and made available. Continuing development on content for this area is ongoing as the graduate students funded by both the EPSCoR Track 2 and Track 1 projects have been compiling information about a wide variety of data management resources for integration into the portal.

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Michener, William	PD/PI	1
Benedict, Karl	Co PD/PI	1
Cadol, Daniel	Co PD/PI	2
Daniel, Mary Jo	Co PD/PI	11
Stone, Mark	Co PD/PI	1
Crossey, Laura	Faculty	1
Fernald, Sam	Faculty	1
Martinez, Edward	Faculty	1
Seweingyawma, Ramsey	Faculty	1
Wilson, John	Faculty	1
Gurtler, Gretchen	Community College Faculty	1
Jones, William	Community College Faculty	1
Juarros, Elizabeth	Community College Faculty	1
Terry, Tracy	Community College Faculty	1
Chee, Chelsea	Other Professional	1
Hart, Tracy	Other Professional	1
Allen, Christopher	Technician	6
Barrett, Hays	Technician	1

Name	Most Senior Project Role	Nearest Person Month Worked
Hudspeth, William	Technician	1
Scott, Soren	Technician	1
Gregory, Angela	Graduate Student (research assistant)	4
Hawk, Anjanette	Graduate Student (research assistant)	1
Irwin, Suzanne	Graduate Student (research assistant)	1
Miller, Sarah	Graduate Student (research assistant)	1
Wine, Michael	Graduate Student (research assistant)	1
Zakia, Afrin	Graduate Student (research assistant)	4
Zhang, Su	Graduate Student (research assistant)	1
Arviso, Kevin	Undergraduate Student	1
Battle, Bobbie	Undergraduate Student	1
Begay, Melanie	Undergraduate Student	1
Ferguson, Christina	Undergraduate Student	1
Saleem, Hassan	Undergraduate Student	1
Vasquez, Dolores	Undergraduate Student	1
Connealy, Selena	Other	2

Full details of individuals who have worked on the project:

William K Michener
Email: wmichene@unm.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Project Director

Funding Support: UNM

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Desert Research Institute	Academic Institution	Reno and Las Vegas, NV
George Mason University	Academic Institution	Fairfax, VA
New Mexico Tech	Academic Institution	Socorro, NM
Sierra Nevada College	Academic Institution	Incline Village, NV
Southwestern Indian Polytechnic Institute	Academic Institution	Albuquerque, NM
University of Kansas	Academic Institution	Lawrence, KS
University of Nevada, Las Vegas	Academic Institution	Las Vegas, NV
University of Nevada, Reno	Academic Institution	Reno, NV
University of New Mexico	Academic Institution	Albuquerque, NM
University of New Mexico - Valencia Campus	Academic Institution	Los Lunas, NM
University of Texas, El Paso	Academic Institution	El Paso, TX
Western Nevada College	Academic Institution	Carson City, NV
HDF Group	Other Nonprofits	Boulder, CO
Luna Community College	Academic Institution	Las Vegas, NM
Mesalands Community College	Academic Institution	Tucumcari, NM
Navajo Technical College	Academic Institution	Crownpoint, NM
Nevada State College	Academic Institution	Las Vegas, NV
Nevada System of Higher Education	Academic Institution	Reno and Las Vegas, NV
New Mexico Highlands University	Academic Institution	Las Vegas, NM
New Mexico State University	Academic Institution	Las Cruces, NM

Full details of organizations that have been involved as partners:

Desert Research Institute

Organization Type: Academic Institution
Organization Location: Reno and Las Vegas, NV

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: WC-WAVE Research Institution

George Mason University

Organization Type: Academic Institution
Organization Location: Fairfax, VA

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Individual collaborator is Phil Yang - PI on a submitted NSF EarthCube Building Blocks proposal for which Benedict is a Co-I. Focused on cloud computing for geo-science.

HDF Group

Organization Type: Other Nonprofits
Organization Location: Boulder, CO

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Individual collaborator is Ted Haberman - PI on NSF DIBBS proposal with whom Benedict is an unfunded collaborator. Focused on metadata evaluation and improvement.

Luna Community College

Organization Type: Academic Institution
Organization Location: Las Vegas, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

Mesalands Community College

Organization Type: Academic Institution
Organization Location: Tucumcari, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

Navajo Technical College

Organization Type: Academic Institution
Organization Location: Crownpoint, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

Nevada State College

Organization Type: Academic Institution
Organization Location: Las Vegas, NV

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

Nevada System of Higher Education

Organization Type: Academic Institution
Organization Location: Reno and Las Vegas, NV

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: WC-WAVE Research Institution

New Mexico Highlands University

Organization Type: Academic Institution
Organization Location: Las Vegas, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Partner for Undergraduate Modeling & Visualization Network

New Mexico State University

Organization Type: Academic Institution

Organization Location: Las Cruces, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: WC-WAVE Research Institution

---

New Mexico Tech

Organization Type: Academic Institution
Organization Location: Socorro, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: WC-WAVE Research Institution

---

Sierra Nevada College

Organization Type: Academic Institution
Organization Location: Incline Village, NV

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

---

Southwestern Indian Polytechnic Institute

Organization Type: Academic Institution
Organization Location: Albuquerque, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

---

University of Kansas

Organization Type: Academic Institution
Organization Location: Lawrence, KS

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Individual collaborator Aimee Stewart -CO-I on NASA ACCESS project in support of enhancing OGC data services hosted by EDAC with semantic provenance data.

University of Nevada, Las Vegas

Organization Type: Academic Institution
Organization Location: Las Vegas, NV

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: WC-WAVE Research Institution

University of Nevada, Reno

Organization Type: Academic Institution
Organization Location: Reno, NV

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: WC-WAVE Research Institution

University of New Mexico

Organization Type: Academic Institution
Organization Location: Albuquerque, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: WC-WAVE Research Institution

University of New Mexico - Valencia Campus

Organization Type: Academic Institution
Organization Location: Los Lunas, NM

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

University of Texas, El Paso

Organization Type: Academic Institution
Organization Location: El Paso, TX

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Individual collaborator Deana Pennington - PI on a current NASA

funded ACCESS project in support of enhancing OGC data services hosted by EDAC with semantic provenance data. PI on an NSF funded CI-TEAM project of which Benedict is a participant

Western Nevada College

Organization Type: Academic Institution
Organization Location: Carson City, NV

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: PUI partner for Undergraduate Modeling & Visualization Network

Have other collaborators or contacts been involved? Yes

Impacts

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

WC-WAVE will enable integration of creative observation and analytical strategies using advanced modeling approaches and CI in a virtual watershed platform. The WS research and CI are critical to understanding and predicting complex responses to climate and hydrologic change and cannot be accomplished by the Consortium members individually. In particular, the VW platform will allow researchers to integrate experimental and observed data, models, and visualization capabilities that can simulate watershed drivers and dynamics and lead to new discoveries. Project activities thus far have focused on recruiting students, organizing the project and advancing the Year 1 objectives. Year 2 will build upon these initial efforts and begin to provide more substantive results for all components. Collaboration among Tri-State researchers has increased competency in Virtual Environments and has impacted university level training activities across all Tri-State institutions. The CI-Vis design documentation efforts have resulted in the early development of curricula that will aid in the development for cross-state courses targeting desktop and Web-based Virtual Environments and front end interfaces. The successful development of data management capabilities allow researchers to focus on the scientific problems instead of ìwrangling data bitsî associated with their research, which will significantly increase the efficiency of the watershed modeling and research process. By explicitly embedding efficient data management principles into the systems and workflows within which models are executed, the knowledge about model products (documentation/metadata), the products themselves, and information about model execution may all be effectively captured and managed. This will increase the value of data generated as a product of the WS modeling work. Finally, by increasing the focus on data management principles as part of the modeling workflow, the participating WS team and their students gain a greater understanding and appreciation of effective data management, both of which should translate into other research projects in which they participate.

The Graduate Interdisciplinary Training (GIT) is developing a cadre of scientists with experience in conducting interdisciplinary team science with colleagues both co-located and at a distance. Evaluation results of this experience will contribute to the Science of Team Science (SciTS), informing other large projects of key program elements required for successful collaboration. We also anticipate that research publications and presentations based on these interdisciplinary collaborations will lead to transformative approaches in watershed science. The UVMN employs an innovative approach of pairing faculty and students as co-learners who will work together to implement an educational module, drawing on their different perspectives. The outcomes of this work will inform research and practices in undergraduate STEM education at non-research institutions.

What is the impact on other disciplines?

Collaborations between the projectís watershed and computer team members concerning visualization and database needs and VE possibilities have resulted in increased understanding of watershed and computer science for all participants. The March Tri-state Meeting in Boise, Idaho enabled significant breakthroughs towards understanding the culture of each participating team. Discussions between CI-Vis and WS team members resulted in shared understanding of visualization desires and needs and what VEs can provide. These discussions have resulted in a change in how WS and CI teams will perform project tasks and research. A secondary disciplinary impact of the work being done by the CI-Data team is in the area of information management, particularly in the development of information architectures that enable effective use of research data products as a complement to discovery of those products. The focus on developing the capacity to provide unified data discovery and access services, which enable smart interaction with remote datasets, extends the information management model beyond file-based delivery of datasets for which discovery services exist. The consideration of data access in support of both visualization and modeling also begins to generalize the access model beyond meeting a single set of requirements. While still not generalized, this expanded requirement set broadens the thinking about the core strategies that must be employed when configuring a data management and delivery system in support of multiple use cases.

What is the impact on the development of human resources?

The WC-WAVE project has provided new research and training opportunities to many groups, including undergraduate and graduate students, and faculty members from both PUIs and research institutions. The primary impact on human resources by the WS team is the training of graduate students. The graduate students completed a ìSnow Campî training experience that brought together students and faculty from across the four component teams. The shared experiences of this field endeavor provided a level of understanding and collaborative bonding that otherwise would not have been achieved through web-based or in-person meetings. The project has allowed the CI-Vis team to hire several students and begin their training in the computation and visualization field. This has already motivated several undergraduate students to consider staying for graduate school. For some that are in single parent households, graduate school would be impossible without this project. Within CI-Data, both graduate and undergraduate students participating in the project, and the additional graduate students that participated in the Data Management Training session in New Mexico, have gained knowledge and expertise that have broadened their education beyond the scope of typical academic courses. Through GIT opportunities, WC-WAVE participants will have gained new skills, knowledge, and positive attitudes that will enable them to work in interdisciplinary teams productively. They are developing additional understanding of how modeling and visualization can inform and support watershed research. In the UVMN, undergraduate students, several from minority serving institutions, and their faculty partners will gain experience using available visualization and modeling technologies and software. With these new skills, they will be positioned to infuse these technologies into existing undergraduate STEM courses, providing an enhanced educational experience for scores of additional undergraduate students. It is anticipated that participation in the UVMN will encourage students to persist in STEM and that faculty will find renewed enthusiasm for teaching these courses. By intentionally structuring meetings and activities to foster interactions between graduate students and UVMN participants, we anticipate both groups will develop greater appreciation for the resources and capabilities of the other in both research and education and find ongoing opportunities to collaborate, narrowing the divide that can exist between PUIs and research institutions.

What is the impact on physical resources that form infrastructure?

The increased computational, data storage, and network capacity that has been supported by or leveraged from other improvement funds all lay the foundation for the data integration services that are being developed in support of the CI-Vis and CI-Data objectives. These resources are the necessary basis for handling increasingly large replicated datasets between the states, and providing responsive services based upon those data. This

effort therefore provides all three states with resources that will enable them to engage in more competitive research.

What is the impact on institutional resources that form infrastructure?

The project has raised the profile of experimental watersheds in the view of administrators at all the universities involved in the project. The visualization project effort is fostering collaboration outside of the project both on the campuses of the faculty members and across the campuses. We already have a publication submitted and several in planning stages that include authors outside of our normal research groups. This is also leading to sharing of developed resources for visualization training and courses. Participants in the UVMN will be modifying existing undergraduate STEM courses to infuse additional content related to watershed modeling and visualization. Evaluation of the impacts of these changes could lead to institutional changes of course syllabi to incorporate more real-world science.

What is the impact on information resources that form infrastructure?

The project requires using previously collected data from several experimental field sites. Each site has its own data services system. However, none of the data from these sites has been used in an integrated modeling project such as this. The current project will provide a model for how experimental watersheds can address important scientific challenges using a common data preservation platform. The data discovery, access and integration services developed by this project will significantly streamline the process of data access and use by researchers in their work. By being able to deliver data products in formats that are needed, representing required parameters, these data services will introduce a degree of flexibility and usability for data that encourages even greater experimentation with modeling and visualization capabilities, ultimately enabling better and more efficient science. Given the longer-term data replication model for the project, data preservation will also be enhanced through the work of the CI-Data team. In particular, by leveraging the DataONE Tier 4 member node replication model we will achieve data replication across the tri-state consortium, enhancing both the security and availability of the data products generated by the project. As part of UVMN, we are establishing an online collaboration site through which workshop materials and educational modules will be developed and shared among participants and, as appropriate, made available to faculty and students at other PUIs.

What is the impact on technology transfer?

The project is continuing the use and development of the GSToRE as a unified data management platform that supports diverse data types, metadata content and multiple Application Programming Interfaces (APIs) for interacting with external networks. This effort will increase the likelihood that this platform may evolve to the point where it will be more broadly used, either directly, or as an exemplar for general purpose, service-enabled data management, discovery, access and delivery.

What is the impact on society beyond science and technology?

One of the outputs of this project is a web-based visualization platform for several of the watersheds. This, coupled with the online data availability will allow people who are not scientists to view the data that has been collected over the years on these watersheds. The project will also provide stakeholders and educators with the ability to use the VE to better manage and understand the watersheds from the project and the ability to better model other watersheds. Nearly half of all undergraduates in the US attend a community college or other PUI. By providing modeling and visualization experiences in watershed research to students and faculty from these institutions, we are reaching individuals who are likely to have a variety of roles in their local communities, outside the academic world. They can translate their improved understanding of the benefits and limitations of watershed modeling and visualization to inform decisions they make in their civic or other community support roles. Having had direct experience working with academic researchers, they will gain a better understanding of the goals and approaches used in science and how to better interpret scientific results and communicate those results to their

family, friends and co-workers.

Changes/Problems

Changes in approach and reason for change

We have no changes to the goals and major objectives of the project. However, we have changed some of the models that will be used in the VWP. The proposal stated that we would use four models in all test watersheds. We now propose to use seven models to better incorporate the ongoing research agendas of the participating faculty and students and the models were specifically selected to match individual watershed characteristics. Each test watershed has active research programs involving modeling exercises. We will use the VWP to enhance these ongoing research activities and simultaneously ensure that the VWP incorporates sufficient flexibility for future accommodation of new watershed and model combinations. This will not affect the goals of the project. Rather, it will provide incentive for faculty to more fully engage in the modeling activities. Because time was taken to re-visit which models to use, there has been a slight delay in the work on the Visualization to Watershed adapters so that the CI-Vis team could focus on the model integration discussions with the WS team.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures

Because the project began at the beginning of an academic year, most universities were not able to recruit new students for the fall semester. Consequently, minimal expenditures were made in the category of student salaries.

Year 1 budget, $600,000. $324,170 has been expended or encumbered via contracts and subawards, with $275,830 unobligated. The remainder will be expended via researcher/student salaries over the course of the summer months. Any unspent funds will rollover into Year 2.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.

Award specific reporting requirements are addressed throughout the above narrative, as outlined in the Programmatic Terms and Conditions (PTC).

Jurisdiction Specific Terms and Conditions
6.1 In each annual report, identify which of the products entered in the Products section represent collaborations between researchers from two or more state partners (Nevada, New Mexico and Idaho).

Tri-State Consortium partners developed nine collaborative products in Year 1, listed below.

Publications:
Dascalu, Sergiu. Scientific Collaboration in Virtual Environments: The WC-WAVE Project (invited talk). Proceedings of Collaborative Technologies and Systems (CTS-2014). Accepted. NV, NM, ID

Anderson, J.W., Smith A.M.S., Tinkham, W.T., Kliskey, A.D., Kolden, C.A., Alessa, L.,Harris, F., Keefe, R.O., and Gosz, J.R. Virtualized Landscapes: A New Paradigm for SocialEcological System Science. Landscape and Urban Planning. Under Review. NV, ID

Website:
Nevada Research Data Center (NRDC), http://sensor.nevada.edu/NRDC/. NV, NM

Other Products:
1) Databases:
NCCP data collection files. NV, NM

2) Software or NetWare:
Visualization Front End for Desktop Environment. Reynolds Creek-East Fork. NV, ID, NM
Visualization Front End for Desktop Environment. Dry Creek Watershed. NV, ID, NM
Server infrastructure for data sharing. NV, NM
Experimental test adapter for model integration with the CSDMS framework. NV, ID

6.2 In each annual report, list proposal submissions and awards that represent collaborations between researchers from two or more state partners (Nevada, New Mexico and Idaho). Include PI and Co-PI names, institutions, submission date, program to which submitted, title of proposal and amount requested/awarded.

No collaborative proposals were developed in Year 1.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
Combined Broadening Participation Table.pdf	PTC 4.1.b Broadening Participation Table	William Michener	04/30/2014