Project Summary

Introduction. The Western U.S. faces daunting challenges. Populations are increasing; demand for fresh water exceeds the available supply; and regional and global climate change and variability affect natural resources, disturbance regimes, and the region's economies and citizens. In 2008, Idaho, Nevada, and New Mexico independently submitted NSF EPSCoR Track 1 Research Infrastructure Improvement (RII) proposals that shared a common theme and addressed a global challenge: climate change and its effects on water resources, ecosystems, and the environment. Following up on their Track 1 RII awards, the three states formed a Consortium to pursue cyberinfrastructure (CI) improvements that would leverage their resources so that the cumulative impact of NSF RII investments in the three states could exceed the sum of the parts. The impetus for this Track 2 proposal has been the recognition of the complexity and scale of the scientific challenge and subsequent ramifications for science, education, and economic development

Project Goal and Objectives. *The goal of this project is promote knowledge transfer to scientists, educators, students, and citizens within and beyond the Consortium by enhancing state CI, and to enable the community science that is required to address regional to global scientific and societal challenges.* To meet this goal, the Consortium proposes three high priority objectives:

1. Increase connectivity and bandwidth. Significant effort will focus on promoting communication and collaboration by improving connectivity infrastructure within the Consortium. Proposed and future Consortium efforts related to improving research competitiveness, STEM education, and economic development rely on this basic infrastructure.

2. Enhance data and model interoperability. The Consortium will promote discovery by supporting community-based climate change science through enhanced interoperability between models and other software components, improved access to and usability of Consortium data products through the adoption of standards-based data management and access models, and new data assimilation, analysis, and visualization capabilities.

3. Utilize CI to integrate research with education. The Consortium will enhance learning by focusing particularly on graduate student and postdoctoral researcher development; extending cyber-enabled science education into middle and high schools and extracurricular programs; and improving outreach to business and industry.

Project activities designed to enable the Consortium to achieve these objectives are described below.

Overarching Outcome. Track 2 investments will enhance the ability for our Consortium to better address 21st Century grand scientific and societal challenges related to climate change through increased competitiveness for research funding and sustained partnerships among our jurisdictions.

Activities designed to increase connectivity and bandwidth (Objective 1). The high speed networking connectivity activities in Track 2 will focus on improving communication and connectivity within and between the states. Each state in the Consortium is in a different phase of CI development and requires different CI to achieve Consortium goals.

Idaho: Idaho will upgrade infrastructure to deliver improved network connections to key university researchers' labs and desktops. Idaho will also work to connect difficult-to-access sites within Idaho by adding to, enhancing, and using the Idaho Regional Optical Network (IRON).

Nevada: The initial focus in Nevada is to increase the connectivity *into* the state network. The next step will be to improve connectivity *within* the state through several networking and video conferencing upgrades, as well as networking monitoring tools across the state.

New Mexico: New Mexico activities will enhance connectivity to academic institutions by establishing a distributed computing and collaboration infrastructure that consists of compute nodes at portals or gateways at Tribal colleges and Hispanic-Serving Institutions throughout the state.

Outcomes from increasing connectivity and bandwidth. EPSCoR Track 2 investments in connectivity will facilitate new data-intensive research, scientific collaborations, distributed experiments, grid-based data analysis, IP videoconferencing, social networking, and cyber-enabled learning. Network

improvements on Consortium campuses will remove bandwidth bottlenecks and allow faculty involved in climate-related research at each university to fully utilize available bandwidth for research and education.

Activities designed to achieve data and model interoperability in support of community science (Objective 2). Community science and virtual organizations are essential for addressing complex, large-scale challenges like climate change. The proposed collaborative CI development will overcome existing challenges by focusing on two closely related activities.

1. Creating a model and software interoperability framework: The team will establish a model and software interoperability framework based on emerging national and international standards, along with scenarios and applications that make use of that framework. The framework will allow users to specify, maintain and update—through a central user interface and a common methodology—a collection of software tools, and the interconnections between tools needed to accomplish climate research tasks.

2. Building an interoperable data archive: The Consortium will implement a data archive model that is based upon open data and metadata standards and supports standard data interoperability models. The interoperable data archive will enable streamlined discovery of and access to data products generated by all three state EPSCoR programs. These activities will use web interfaces to communicate the availability of data, models, training, and activities of researchers; will leverage existing national/international resources; and will make any code that is developed available through open source outlets.

Outcomes from achieving data and model interoperability: EPSCoR Track 2 investments will provide new model and data interoperability solutions and an integrative software framework that will transform exploration, experimentation, and innovation in climate research. Project activities build upon existing resources within Idaho, Nevada, and New Mexico, and are designed to leverage other major NSF-supported initiatives (including CUASHI HIS, GEON, and CSDMS). The project will significantly reduce the difficulty in finding, accessing, and using the diverse data products available in the Consortium. Consortium results (data and models) and resources (archives) will become readily accessible to the broader community of environmental scientists, decision makers, students, and the public.

Activities utilizing CI to integrate research with education (Objective 3). The Consortium faces many challenges in helping to meet the national need for a 21st century workforce that is scientifically capable and CI-literate. Using climate change as the underlying theme, we propose three activities designed to expand CI awareness, enhance use of CI, and better integrate quantitative reasoning, data analysis, and climate change modeling with education.

1. CI training workshops: A series of training opportunities to develop CI capacity and hands-on experience with climate modeling and scientific information systems will be provided for students, postdoctoral associates, and faculty.

2. Cyberlearning materials: New cyber-enabled curriculum and education materials will be created and implemented for middle school and high school science education.

3. Industry CI Days: An Industry CI Days program will be piloted in NM with business and industry as a target audience to increase CI awareness and promote economic development opportunities.

Outcomes from increased integration of research and education: EPSCoR Track 2 investments in education and training programs will build human resources capacity in our Consortium by increasing awareness, skills, and knowledge in the areas of climate change and cyberinfrastructure. The activities will support a “students in STEM” pipeline approach that begins with middle and high school education, extends to professional training for graduate students, postdoctoral associates, and faculty, and promotes CI awareness to business and industry. These new investments will complement Track 1 resources that support undergraduate engagement in climate change research.

Communication and Dissemination. We will foster scientific literacy and improve educational and research capacity within the Consortium through three dissemination and communication activities: (1) establishing effective internal communications among the Consortium’s partners to enable efficient sharing of data and information; (2) creating coordinated mechanisms to communicate project results, benefits, and processes to scientists, citizens, and stakeholders within the Consortium and other EPSCoR jurisdictions; and (3) developing cyberlearning tools for educational outreach. A centerpiece for communication is an annual tri-state CI meeting that will include Track 1 and 2 members. Faculty,

graduate students, and postdoctoral associates will share ideas and present their work at the meeting. *These tri-state meetings represent an unprecedented leap in collaborations and information sharing between our states.*

Management, Coordination, and Evaluation. The Consortium's management and coordination plan draws on the strengths of each state's EPSCoR program structure. To ensure timely progress and long-term success, there are four primary elements in the CI management structure: (1) State Committees; (2) EPSCoR offices and Management Team; (3) CI Component Teams; and (4) external evaluation and assessment. The Management Plan also includes a postdoctoral mentoring plan. Communication mechanisms to support project management include the annual tri-state CI meeting, NSF EPSCoR Project Director and National meetings, and online video and/or teleconferences. The External Advisory Committee and External Evaluator will evaluate progress and provide the Management Team with input to help ensure successful attainment of the project's goals.

Diversity. The Consortium is committed to improving access to cyberinfrastructure for underrepresented groups and geographically disadvantaged populations and to increasing diversity in the 21st Century workforce. Three principal activities will help the Consortium to make meaningful progress in achieving diversity goals: (1) invest in the connectivity solutions and human resources that enhance access to CI; (2) maximize geographic, ethnic, cultural, physical, and gender diversity in Track 2 programs; and (3) develop realistic accountability metrics and mechanisms. Close coordination with and leveraging of Track 1 resources are central to our diversity plan.

Sustainability. Consortium CI development activities will be sustained by: (1) commitments to long-term support by individual states and institutions for Track 2 activities; (2) development of new proposals that make use of and provide continued CI support; and (3) creation of new partnerships and strengthened collaborations (e.g., CSDMS, NCAR, National Laboratories, state and federal agencies).

Intellectual Merit and Broader Impacts:

Intellectual Merit: Climate change affects all natural environments. In the Western U.S., climate change impacts may be especially pronounced due to the tight coupling between climate and regional hydrology, and its ramifications for the water supply, disturbance regimes (e.g., fire, drought), the region's economy, and quality of life. The proposed cyberinfrastructure developments will enable atmospheric scientists, climatologists, hydrologists, engineers, social scientists, economists, and others to more effectively share standardized and interoperable data and models, and to more easily develop regionally coupled atmosphere-land surface-hydrology-socioeconomic models. Consortium institutions and states will be linked to more than 200 other Internet2 universities, government research laboratories, companies, and many research facilities throughout the world, facilitating data-intensive research, collaborative development, distributed experiments, grid-based data analysis, and experimentation using 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 objectives and transform the way our states do research. Moreover, Track 2 investments will support effective participation in national and international virtual organizations—e.g., National Ecological Observatory Network, the Consortium of Universities for the Advancement of Hydrologic Science, Inc.—that work to solve problems associated with global climate change.

Broader Impacts. The proposed CI investments in the Consortium will achieve broad impact and add value by leveraging existing resources and infrastructure within the institutions, jurisdictions, and regions. The institutions that will benefit from increased connectivity include rural institutions and those that serve Hispanic and Native American students and faculty. Open access to the data and models developed within the Consortium and made available through the data archive and the model interoperability framework ensure that scientific products can be broadly disseminated and readily used by scientists, engineers, and students throughout the world. Moreover, the project will make usable high-quality environmental data, information, and models available for STEM education and outreach. The Consortium's education programs are designed to have far-reaching impact by: (1) developing new CI skills and climate modeling expertise for graduate students, postdoctoral associates, and faculty; (2) integrating cyberlearning and climate change science into middle and high school science education, especially targeting rural schools and schools that reach Hispanic and Native American students; and (3) developing a Industry CI Days Program that promotes CI awareness in business and industry.