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Proposal Title : **Collaborative Development of a Climate Change Curriculum for Classrooms in the Intermountain West**

Proposed Start Date	Proposed End Date	Total Budget	Year 1 Budget	Year 2 Budget	Year 3 Budget
11 / 01 / 2010	**10 / 31 / 2013**	**547,727.00**	**253,085.00**	**167,668.00**	**126,974.00**

SECTION II - Application Information

NASA Program Announcement Number	NASA Program Announcement Title
NNL10ZB1011C	**Global Climate Change Education (GCCE): Research Experiences, Modeling & Data**

For Consideration By NASA Organization *(the soliciting organization, or the organization to which an unsolicited proposal is submitted)*
NASA , Headquarters , Office of Education , Integration

Date Submitted	Submission Method	Grants.gov Application Identifier	Applicant Proposal Identifier
	Electronic Submission Only		

Type of Application	Predecessor Award Number	Other Federal Agencies to Which Proposal Has Been Submitted
New		

International Participation	Type of International Participation
No	

SECTION III - Submitting Organization Information

DUNS Number	CAGE Code	Employer Identification Number (EIN or TIN)	Organization Type
075746271	**4B807**	**826000945**	**2A**

Organization Name (Standard/Legal Name)	Company Division
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SECTION V - Certification and Authorization

Certification of Compliance with Applicable Executive Orders and U.S. Code

By submitting the proposal identified in the Cover Sheet/Proposal Summary in response to this Research Announcement, the Authorizing Official of the proposing organization (or the individual proposer if there is no proposing organization) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in the two Certifications and one Assurance contained in this NRA (namely, (i) the Assurance of Compliance with the NASA Regulations Pursuant to Nondiscrimination in Federally Assisted Programs, and (ii) Certifications, Disclosures, and Assurances Regarding Lobbying and Debarment and Suspension.

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Authorized Organizational Representative (AOR) Name	AOR E-mail Address	Phone Number

AOR Signature *(Must have AOR's original signature. Do not sign "for" AOR.)* **Date**

PI Name : **Stephen Mulkey**	NASA Proposal Number
Organization Name : **University Of Idaho, Moscow**	**TBD on Submit**
Proposal Title : **Collaborative Development of a Climate Change Curriculum for Classrooms in the Intermountain West**	

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International Participation **No**	U.S. Government Agency		Total Funds Requested **0.00**

PI Name : **Stephen Mulkey**	NASA Proposal Number
Organization Name : **University Of Idaho, Moscow**	**TBD on Submit**

Proposal Title : **Collaborative Development of a Climate Change Curriculum for Classrooms in the Intermountain West**

SECTION VII - Project Summary

Although some of the most profound effects of anthropogenic climate change are apparent in the Intermountain West, the public, including Native peoples of this region, are largely uninformed about the science and impacts of climate change. In order to address this systemic lack of understanding of the science of climate change, we propose a program composed of three initiatives for collaborative teacher training and curriculum development. Teacher and student understanding of the NOAA standards for climate science literacy will be the primary learning objectives of this project, and these standards will be used for evidence-based evaluation. The management team for this project includes experts in climate, social, and education sciences.

Initiative I: Faculty of select school districts in northern Idaho, northeastern Washington, Boise, and the Pocatello region will be engaged in the collaborative development of teaching/learning modules and a design for teacher training in climate change science. Graduate students and experts will travel to workshops at these schools where teachers will be included as members of module development teams. The curriculum will explicitly include cultural and resource issues relevant to the local communities and to students of the Spokane, Nez Perce, Coeur d¿Alene, and Shoshone-Bannock tribes. Initiative II: The curriculum created in the first initiative of the program will be adapted for use in distance learning environments and distributed throughout the secondary school systems of Idaho in collaboration with the state-sponsored Idaho Digital Learning Academy and the Idaho Education Network. The project will create an Internet community where teachers learn from each other and exchange teaching tools. Initiative III: The curriculum components from Initiatives I & II will be adapted for use in college freshman-level instruction, and instructors from regional community and tribal colleges will be trained at workshops in climate change science and instruction. NASA Idaho Space Grant will co-sponsor these workshops.

Curricular materials will be designed to meet state and national standards for STEM education, and teachers and students will be assessed for their understanding of standards for climate science literacy. Various NASA products will be used for the creation of: (1) model-based simulations of snowpack and regional hydrology; (2) model-based simulations of forest and shifting forest climate zones; (3) simulations of physical and biophysical changes regionally and globally; and (4) region-specific lesson plans. Some modules will involve a hands-on experience for estimation of greenhouse gas emissions and carbon footprints. Unique features that are central to the success of this program include: (1) the collaboration of teachers with scientists and graduate student fellows in climate science and related fields; and (2) the explicit inclusion of place-based resource and cultural issues relevant to the Native peoples of the region.

Evaluation of this program will be conducted according to protocols provided by an external evaluator. Teacher understanding of climate change will be evaluated for relevance to (1) standards for climate science literacy, (2) local and regional impacts of climate change, and (3) means of mitigation and adaptation

Collaborative Development of a Climate Change Curriculum for Classrooms in the Intermountain West

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Collaborative Development of a Climate Change Curriculum for Classrooms in the Intermountain West; ***Mulkey et al. 2010***

Executive summary
Although some of the most profound effects of anthropogenic climate change are apparent in the Intermountain West, the public, including Native peoples of this region, are largely uninformed about the science and impacts of climate change. In order to address this systemic lack of understanding of the science of climate change, we propose a program composed of three initiatives for collaborative teacher training and curriculum development. Teacher and student understanding of the NOAA standards for climate science literacy will be the primary learning objectives of this project, and these standards will be used for evidence-based evaluation. The management team for this project includes experts in climate, social, and education sciences.

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I. Introduction

Owing in part to climate change, Idaho and the Intermountain West are already undergoing momentous environmental and economic changes that will span the next few decades. It is critically important that high school students graduate with a basic understanding of how climate change is likely to affect their lives and the world they live in. As this complex and controversial topic has been politicized, it is increasingly difficult for science teachers to find neutral, objective sources of information. Because many teachers are unclear about what constitutes natural versus human-caused variation in climate, they are poorly equipped to counter the abundant misinformation that can be found in various media outlets. Both students and teachers frequently lack an understanding of such basic issues as the difference between climate and weather, the expected time frame and effects of human-caused climate change, and why peer-reviewed scientific literature is considered the primary source for our understanding of the earth's climate system. In contrast to urban schools in states where climate change is accepted as having had a material impact (e.g., Florida, Alaska), the largely rural schools of the Intermountain West appear to have less instruction in climate change in their curricula. There is considerable anecdotal evidence suggesting that it is common for teachers in the school systems of the Intermountain West to avoid this topic because of its political baggage and their lack of familiarity with the relevant science.

Scientists as part of the solution. Scientific information is important to the public's subjective assessment of climate change, and the public's confidence in scientists is paramount (Kellstedt et al., 2008). The controversy surrounding climate change exists in a cultural context that is characterized by some as widespread scientific illiteracy fostered by the public's general disdain for science; however, a recent survey conducted by the Pew Research Center (2009) indicates that the US public likes and respects science and scientists in general. We propose a project wherein scientists will work collaboratively with teachers in select school districts of northern Idaho, northeastern Washington, and the Boise and Idaho Falls-Pocatello regions of southern Idaho to develop a climate change curriculum. This new curriculum will allow teachers direct and ongoing access to scientists, scientists in training, and the latest understanding derived from peer reviewed scientific literature. Teachers will work with project scientists (Mulkey, Abatzoglou, Humes, Kolden, Vierling, and Walden) and science graduate students specifically recruited to the University of Idaho for this project and trained in the body of peer-reviewed observations that have led scientists to the conclusion that greenhouse gases are responsible for a significant part of observed climate change over the last 50 years. NASA products, including downscaled General Circulation Models, visualizations from Giovanni and relevant MODIS products, and Landsat data, will be centerpieces of our teaching materials. We will collaborate with the Earth System Science Education Alliance (ESSEA) and use products from My NASA Data to develop Teaching/Learning Modules (TLMs) based on the seven principles of climate science literacy (NOAA) that meet state and national standards in the Earth Sciences. Collaboration with teachers will focus on specific issues that arise in the teaching of basic earth science, and the curriculum will include established techniques for explaining the complexities of climate. The project's team of scientists and science educators (Gregson, Johnson, Kern, and Saul) will collaborate with teachers to explicitly address issues such as the role of the sun, cosmic rays, air temperatures (as revealed through satellite and ground-instrument measures), and the impact of greenhouse gases on past climates. Experts familiar with communities of the

Intermountain West (Galindo, Kern, Reynolds, and Saul) will develop place-based cultural aspects of climate impacts for inclusion in TLMs.

Climate change in the Intermountain West. Climate in this region is changing at a rate that will greatly transform plant distributions, forests, and agro-ecosystems within the lifetime of students in secondary school today (Rehfeldt et al., 2006; Salathé et al., 2008). The accelerated arrival of spring has resulted in a 30% decline in average March 1st snowpack water content (Cayan et al., 2001; Mote et al. 2005). In warm springs snow melts earlier resulting in fire seasons 78 days longer than 20 years ago, changes in stream flow critical to an arid region, bark beetle-induced tree mortality, and altered patterns of tree mortality and establishment (Germino et al., 2002; Kurz et al., 2008; Westerling et al., 2006). Warming and summertime drying over the next 50 years will differentially affect growth rates of forest tree species in the Pacific Northwest, including forests in Idaho and parts of Montana and Wyoming (Latta et al., 2009). Snow pack and stream flow are expected to further decrease as warming progresses, bringing major changes to fisheries and fostering widespread wildfire and insect outbreaks (Karl et al., 2009). There is little doubt that climate change will negatively affect important industries related to fisheries, forestry, agriculture, and amenity-based use of the environment. It is crucial that teachers prepare students to understand and respond to these changes. While the science of climate change is central to this project, teachers will also be taught scientific principles relevant to the mitigation of and adaptation to the effects of climate change. As detailed in this proposal, the issues of mitigation and adaptation, in particular, provide strong motivation to include the perspectives and concerns of Native peoples of the region when dealing with climate change in the Intermountain West.

Revisions to previous submission. Reviewers of the previous version of this proposal queried (1) the limited number of schools involved, (2) lack of detail on how NASA products will be used, (3) the lack of a named evaluator and plan, and (4) a marginal impact for the requested level of funding. In response, we have made the following changes: (1) the project has been expanded to include eight schools instead of four and expanded distance programming. Impact will extend over 600 miles from the northern inland Pacific Northwest to southern Idaho, reaching more than 4400 students during the term of funding. (2) We have added four new members to the science team, all of whom are specialists in the use of NASA products. (3) An outside evaluator has agreed to work with this project and an explicit plan is included. (4) Although we have increased our requested level of funding, the total impact of this project has been significantly expanded, requiring graduate students, a postdoctoral associate, and faculty education and science experts to travel to all eight schools and conduct multiple site visits throughout the duration of the project.

II. Objective and significance

Proposal statement. *The primary objective of this project is to deepen teachers' knowledge and understanding of the science of climate change by engaging them in the collaborative development of an effective, place-based climate change curriculum.* Our collaborative training program will provide teachers with the concepts and information necessary to bring climate change science to the classroom. Our project empowers teachers through three linked initiatives, each targeting a different audience. During the first initiative, we will focus on a region that includes parts of northern and southern Idaho and northeastern Washington. We will develop a program to train secondary-level teachers in climate change science through collaboration with

climate scientists to produce TLMs for use in grades 9-12. Because tribes with sovereign status in this region exert direct or indirect influence over land-use policy and a range of natural resources, and because of their longstanding cultural engagement with the natural world, it is of great importance to include the perspective of Native peoples in the curriculum. We will collaborate in the development of TLMs with teachers in secondary schools serving the needs of the Nez Perce, Coeur d'Alene, Spokane, and Shoshone-Bannock tribal communities as well as the general public. After the development and testing of these modules in partnered school systems, the second initiative will involve adaptation of the modules to serve as distance learning programs in secondary schools throughout the broader region, initially working with schools in Idaho through the Idaho Distance Learning Academy (IDLA) and the Idaho Education Network (IEN). During the final initiative of the project, we will modify and expand our TLMs for use in college-freshman level education in community colleges and Tribal Colleges and Universities (TCUs), and support instructors at these institutions in teaching climate change science in a manner consistent with place-based pedagogy relevant to local communities and Native peoples.

Significance. By improving the effectiveness of secondary teachers in addressing the challenging topic of climate change, our program will cultivate a regional understanding of climate change and help prepare a generation of students for the reality that climate change will significantly affect their lives and the lives of their children. Moreover, we will help teachers to empower their students with a sense that they and their communities can effectively respond to climate change. The selected school districts of Idaho and northeastern Washington will generate TLMs that are appropriate for use throughout the region of the Intermountain West that shares elements of increased summer heat and drought, reduced snowpack, increased wildfire, and increased seasonal variability in stream flow.

III. Methodology for teaching climate change science

Educators play a central role in helping students develop an understanding of environmental issues and their possible solutions (e.g., Rickinson, 2007). For example, most teachers convey to their students that people are responsible for many of today's environmental problems, including climate change, water pollution, and ozone depletion, and that these global environmental problems can be addressed with the help of science and technological advances (Papadimitriou, 2004). Because there is a strong relationship between a teacher's knowledge of content and a student's learning (Wiggins & McTighe, 2008), it is troubling that teachers hold numerous misunderstandings and misconceptions about the meaning of the terms "sustainability" and "global climate change" (Spiropoulou et al., 2007). The following subsections outline the importance of content-specific pedagogy, inquiry-based science instruction, and teachers' professional development to our project. This is followed by a detailed description of the three overlapping initiatives of the project.

Science pedagogical content knowledge. A science teacher's effectiveness is strongly related to his or her knowledge of subject matter, curriculum, and pedagogical content knowledge. Pedagogical Content Knowledge (PCK) refers to the discipline-specific combination of academic content and pedagogical methods that best enable a teacher to adapt and transmit a subject's concepts to students (Shulman, 1986). This means that teachers must understand both the structure and the specifics of their discipline, as well as have an ability to select and transform content into appropriate learning activities. While more than 90% of teachers in Idaho are certified in their disciplines (NCES 2008), the primary obstruction to understanding climate

change science is lack of access to expert understanding. Even teachers holding academic degrees in their teaching areas have been found to have highly compartmentalized and poorly organized knowledge of relevant subject matter (Talbert et al., 1993) and a limited understanding of the nature of science (Roehrig & Luft, 2004). Unfortunately, teachers with limited content knowledge are more likely to rely on texts and prescribed curricular materials (Brickhouse & Bodner, 1992), which often lack the most current science content needed for effective teaching (e.g., Trumbull et al., 2005). It is, therefore, important to provide teachers with assistance in understanding the relationship between pedagogical and scientific content (Gess-Newsome, 1999).

Inquiry-based science instruction. One of the keys to the National Science Education Standards reform efforts is teaching science content through inquiry-based instruction (National Research Council [NRC], 1996). Inquiry-based approaches acknowledge that learning the processes of science is as important as learning the facts of science. The approaches employ The Science Learning Cycle, including elements highlighting Engagement, Exploration, Explanation, Elaboration, and Evaluation (Bybee, 1997). Studies have shown that this model motivates student learning and supports higher order thinking including the ability to link the facts with the processes of science (Boddy et al., 2003).

Our work with teachers will focus on enhancing their ability to deliver both hands-on and minds-engaged TLMs that utilize The Science Learning Cycle. This will require teachers to understand and identify important ideas that are the unifying principles of science (Wiggins & McTighe, 2001). With respect to a complex system such as climate, it is important to note that students' conceptions of natural phenomena often differ from scientific explanations (Driver et al., 1985), and such misconceptions can be very resistant to change (Posner et al., 1982). Teachers will be coached in ways to address these prior ideas so that students are encouraged to accept more scientific conceptualizations. One of the most enduring of such misconceptions with respect to climate involves the conflation of climate and weather. Accordingly, we will design TLMs to explicitly address this and similar misconceptions.

Goals for teacher professional development. In order for teachers to more effectively transmit the science of climate change, they must themselves become familiar with both the content of the field and better teaching practice (Darling-Hammond et al., 2009). The collaborative nature of our project this encourages this engagement by involving teachers in the development of materials in collaboration with climate change scientists. The professional development model that this project will implement uses a combination of strategies in order to foster teacher learning through multiple stages of development (Loucks-Horsley et al., 2003). Guskey (2000) outlines five criteria on which to evaluate meaningful professional development experiences for teachers: (1) participants' reaction; (2) participants' learning; (3) organizational impact and support; (4) change in teachers' instruction; and (5) student learning. Through localized workshops conducted by science graduate students and climate scientists, the project will build teachers knowledge of science content, inquiry-based curriculum, assessment, PCK, and strategies for development of science literacy. Workshops will be conducted during teacher development periods in the fall and spring terms, and additional workshops during the summer and site visits will provide support for further refinement of the curriculum and sharing of teaching approaches. During site visits, teachers will be assisted in translating new knowledge

into practice through classroom-based mentoring by scientists, science educators, and other collaborating teachers.

A project website will facilitate communication and the sharing of resources between teachers and project staff. Online teacher support programs, for both pre-service and in-service teachers, have been demonstrated as a means of effectively supporting science teaching through the promotion of reflection on current teaching practices (Annetta & Shymansky, 2006). The focus of the project website will be on creating an online community for professional development. The "community of learners" model has been shown to be more successful in enacting long-term and sustainable change in science-teaching strategies and best practices than the more traditional "instructional" models of professional development (Rhoton & Shane, 2006). Our intention is for the online peer support program to develop into a teacher network that will continue beyond the life of the grant, sustained by UI maintenance of a central server.

Standards-based science education. As we develop the proposed curriculum we will adhere to state and national standards and established principles of climate literacy. The American Association for the Advancement of Science (AAAS, 1993) and the National Science Education Standards (NRC, 1996) have articulated what knowledge a scientifically literate citizen should possess. The National Science Education Standards further provide a coherent vision and direction for reform-based science education to promote scientific literacy for all K-12 students. The results are the "Science Content Standards" that provide guidance for teachers and outcomes for students. This framework is designed around eight specific categories of scientific content: (1) unifying concepts and processes; (2) science as inquiry; (3) physical science subject matter; (4) life science subject matter; (5) earth science subject matter; (6) science and technology; (7) science in personal and social perspectives; and (8) history and nature of science. Our TLMs will draw from the subject areas of life, physical, and earth sciences, while briefly engaging several other categories.

Our TLMs will include elements designed to meet Idaho and Washington state standards for science education. Idaho K-12 Science Standards generally align with five of the eight content clusters suggested by the National Science Education Standards: the nature of science; physical science; biology; earth and space systems; and personal and social perspectives-technology. While there are no content-specific environmental science standards, climate change science provides a multidisciplinary context within which to address all science content standards. In contrast, Washington state science standards are categorized by grade levels, with grades 9-12 focusing on physical science, earth and space science, and life science. In developing our curriculum and materials we will work within the frames of reference provided by both state and national science standards.

TLMs for climate science literacy. The proposed project will develop TLMs for each of the seven principles of climate science proposed by the NOAA and AAAS (2009). Teacher and student comprehension of each of these principles is central to realizing the goals of the project. These seven principles will also form the basis of our procedures for evidence-based evaluation. We will use NASA products and tools in order to facilitate the teaching of each principle.

The NOAA/AAAS principles of climate science literacy are:

- The sun is the primary source of energy for the earth's climate system.

- Climate is regulated by complex interactions among components of the earth system.
- Life on earth depends on, is shaped by, and affects climate.
- Climate varies over space and time through both natural and man-made processes.
- Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
- Human activities are impacting the climate system.
- Climate change will have consequences for the earth system and human lives.

TLMs will be designed as lesson plans that can be adapted for use in either a classroom or distance-learning environment, and will have three parts that reflect the following learning modalities: (1) instructional and didactic; (2) interactive and exploratory; and (3) inquiry-based exercises. Using elements from NASA products, modalities 2 and 3 will be implemented through a computer interface or through field exercises, while modality 1 will include materials available to teachers through the project's web pages, a Wiki, and Apple's iTunes University™ as provided by Apple, Inc.

NASA products for use in the construction of the TLMs. The research team has expertise using a wide range of NASA products to develop science, mathematics, and technology curricula; 32,000 copies of the Earth Systems Connections curriculum (Vierling et al., 2005) have already been disseminated to teachers nationally. The following NASA products have been identified as having elements that will be used in the creation of our TLMs:

- **MODIS.** The project's senior climate scientists (Abatzoglou, Walden) and geophysical scientists (Mulkey, Humes, Vierling) will work with the education team (Gregson, Johnson, Kern, Reynolds, and Saul) and our product specialist (Kolden) to extract region-specific elements from the MODIS catalog of data products.

- **Giovanni.** The online visualization and analysis system provided by the Giovanni interface will be used to develop interactive graphics for inclusion in the TLMs.

- **Earth Observatory.** Text and images from the NASA Earth Observatory web pages will be used as appropriate for TLM content.

- **Images from various NASA sources**, including HINODE (Solar B) and SOHO will be used.

- **Downscaled GISS (Goddard Institute of Space Science) modeling** of regional climate for the Intermountain West available from collaborator Walden will be incorporated.

- **My NASA Data and the Earth System Science Education Alliance (ESSEA).** My NASA Data and ESSEA (funded by NASA) provide lesson plans that can be used in part as elements of the TLMs. We will contribute to the ESSEA storehouse of plans as our project produces relevant material.

Example elements for TLMs. NASA products will be used to develop TLM components that are (1) relatable and recognizable to Idaho and eastern Washington students, and (2) linked to 'on-the-ground' activities and observations. These components will be designed to demonstrate the relevance of abstract climate change concepts to daily activities and recreation enjoyed by the

public. Suggested TLM components, including several relating to outdoor activities and tourism, can include:

(1) Project scientist Abatzoglou has developed the Eastern Washington and Idaho Climate Tracker, a simple interactive tool that allows users to explore time series of monthly climate data and maps of current climate information. A similar tool developed for California is now widely used by researchers, media, teachers, and has been incorporated into ESSEA courses.

(2) Project scientist Vierling will lead a team in developing TLMs relating to forest carbon accounting using the MODIS and IceSAT satellite platforms; land use/albedo change using MODIS, MISR, LANDSAT platforms; and trace gas emissions using MODIS.

(3) A time series of the MOD10 snow cover product for the inland Northwest is linked to Snotel sites in Idaho and used to produce an animation of the visible interannual variability in snow cover. Students will be able to click on the Snotel sites to see the observed time series of snow and temperature data, and click on local ski resorts to understand how many days of skiing this time series converts to.

(4) A time series of Landsat data over 20 years for a popular fishing reservoir is linked to the Idaho Climate Tracker (developed by project scientist Abatzoglou). It is designed to demonstrate the relationships between changing precipitation patterns, lake and river levels, and impacts on fishing.

(5) Pre-, during-, and post-fire images from Landsat, MISR, and MODIS (including reflectance data, MODIS EVI-based phenology, and the MODIS Active Fire product) can be utilized to create animations linked to pictures and data of wildfires being researched by project scientist Vierling and colleagues. An interactive map and animations can highlight how climate change produces a greater frequency of wildfires, which in turn impact wildlife habitat and hunting (a relevant activity for many in the region).

TLMs relevant to climate change mitigation and adaptation. The project will work with the University of Idaho's Sustainable Idaho initiative (Saul, director) to develop TLMs designed for understanding and calculating carbon footprints, greenhouse gas inventories, and energy audits for an appropriate process or entity such as a home, business, farm, or school. The TLMs for climate mitigation will be focused on hands-on activities, including site visits and data collection. Subject matter for these TLMs includes determining operational boundaries for carbon footprints, including upstream and downstream sources of emissions, and life-cycle energy and emissions analysis. Field projects will take the form of service-learning activities requiring students to calculate energy use and associated emissions for local businesses and homes.

Importance of place-based and cultural components of TLMs. Every effort will be made to imbue TLMs with context-specific information reflecting the geography and culture of the students. This is essential for this project because all of our targeted schools (1) serve Native and minority populations with unique cultural ties to the land and climate, (2) are located in landscapes dominated by snowmelt and rural land use issues, and (3) have a cultural identity derived from the history and natural resources of the Intermountain West. An interdisciplinary and intercultural framework of place-based education allows students to develop a stronger

connection between self and the effect of climate change in their lives. Semken & Freeman (2008) note that "in the natural sciences, place-based pedagogy is advocated as a way to improve engagement and retention of students, particularly members of indigenous or historically inhabited communities" (p. 1044).

Overview of three linked initiatives. The project will consist of three overlapping initiatives that will be developed over three years. First, we will work collaboratively with selected schools in Idaho and northeastern Washington in order to create a better understanding of both the science content and teaching methodology. This initiative will initially focus on four schools in which we will bring together secondary school educators, science graduate students, and climate change scientists to develop curricular materials. Four additional schools will be added during the latter half of the first initiative. In the second initiative, we will expand these materials into distance-learning products for use in a wider geographical distribution in the Intermountain West. In the final initiative we will adapt and provide our products to four-year colleges, community colleges, and Tribal Colleges and Universities to further increase the impact of the materials.

Initiative I. Collaboration with teachers in Idaho and northeastern Washington. *The objective of Initiative I is to collaboratively and iteratively develop an effective climate change curriculum with place-based relevance, explicitly including land-use and cultural aspects of Native peoples*. This initiative will have broad impacts in Idaho through the efforts of four graduate students, one postdoctoral associate, and multiple education and science faculty. TLMs will be developed in collaboration with teachers from three partner schools in Idaho and one in Spokane, WA for the initial development of TLMs. Graduate fellows who have been recruited and trained to work with the climate change curriculum project and climate scientists will travel to these schools to organize workshops during teacher professional development periods in spring 2011. Additional refinement of TLMs will occur in collaboration with selected teachers during the summer of 2011, and four additional partner schools will be added through workshops during their respective professional development periods in fall 2011. The sites in table at right are arranged from north to south spanning a distance of over 600 miles by road. In spring 2011 the project will hire a postdoctoral fellow who will specialize in linking science to education pedagogy beginning with the first spring 2011 workshop. The postdoctoral fellow and the project's four graduate students will conduct periodic follow up site visits to the eight partner schools during spring and fall 2012. When possible, we will specifically recruit Native students as graduate fellows.

Initiative I Partner	Location	Team Leaders	Student Population	Timing
Wellpinit	Spokane, WA	Kern / Reynolds	Spokane tribe	Spring 2011
Lake City	Coeur d'Alene, ID	Kern / Mulkey	Public & Coeur d'Alene tribe	Spring 2011
Plummer-Worley	Plummer, ID	Kern / Mulkey	Public & Coeur d'Alene tribe	Fall 2011
Lapwai High	Lapwai, ID	Mulkey / Galindo / Saul	Public & Nez Perce tribe	Fall 2011
Caldwell High	Caldwell, ID	Mulkey / Johnson / Gregson /	Public, tribal, & Hispanic	Spring 2011
Shoshone-Bannock High	Pocatello, ID metro area	Galindo / Mulkey	Shoshone-Bannock tribe	Spring 2011
Highland	Pocatello, ID	Galindo / Mulkey	Public & Shoshone-Bannock tribe	Fall 2011
American Falls High	Pocatello, ID metro area	Galindo / Mulkey	Public & Shoshone-Bannock tribe	Fall 2011

Prior to conducting the first workshop, the graduate fellows will participate in an intensive two-week training session during December 2010 and January 2011 focused on climate change science and education pedagogy. Members of the education team (Gregson, Johnson, and Kern) will incorporate elements of PCK into this workshop. Included in the training session will be assignments requiring students to read and interpret selections from the peer-reviewed literature on climate change and to become familiar with selected NASA products. Elements specific to particular locales and classrooms will be added through collaboration with the recruited teachers as the project progresses. A computer design technician at the University of Idaho will collaborate with the science and education team to develop the TLMs. These TLMs will be used and tested in classrooms by the participating secondary-level teachers during the 2011-12 academic year, with iterative refinement in 2012. Teachers participating in the project will each be given a laptop computer preloaded with essential software, which will afford them access to the project's computer-based resources (including Elluminate™ conference capability, a Wiki, and iTunes University).

Letters of commitment are appended for all partner schools except those in the Pocatello region. These three schools have an ongoing relationship with UI and their Native populations of Shoshone-Bannock students are partnered with UI through a Memorandum of Understanding. A letter from the UI Tribal Liaison describing this relationship is attached.

The project will engage UI scientists associated with the recently funded Idaho NSF EPSCoR (Experimental Program to Stimulate Competitive Research) program in climate change as a source of materials for development of the TLMs. Our project climate scientists (Walden and Abatzoglou) and biogeophysical scientists (Mulkey, Humes, Kolden, and Vierling) have extensive experience with a wide variety of physical and natural systems that have relevance to the Intermountain West. This expertise will allow us to build a rich set of TLMs that will address the NOAA climate literacy standards and make geographically relevant, cutting-edge climate change science accessible to teachers in our region. Our project team has previous experience working within the NASA and ESSEA frameworks to create similar curricular materials for diverse learners within the context of earth system science (Vierling et al., 2005, 2006; Glasson et al., 2003), conducted by teams of faculty, graduate students, and practicing teachers similar to those proposed for the current project. In addition, the Idaho NSF EPSCoR project contains a strong climate change outreach effort throughout the elementary and secondary levels that we will leverage to extend the impact of the new TLMs in the regional educational community. The Idaho Education Network (IEN), which supplies high-speed Internet connectivity to over 200 schools across the state and has connections to Wyoming and Utah will be critical to this effort.

Initiative II. Dissemination of TLMs through distance learning. *The objective of Initiative II is to adapt and broadly disseminate the products of Initiative I to teachers who are directing classes that include distance learning components.* Because the place-based TLMs developed for Initiative I are relevant throughout much of the Intermountain West, it is appropriate that they be made widely available. The science and education teams will develop lesson plans that are functional in the distance-learning environment.

During spring 2012, we will modify the TLMs for use in the distance-learning environment. Our graduate fellows, postdoctoral associate, and distance-learning specialist (Johnson) will work together with a computer graphics specialist to develop modules that are easily adapted to

common distance-learning platforms such as Blackboard™, Elluminate™, podcasts distributed through iTunes University™, and a Wiki created for this project. Facilitated by dedicated laptops distributed to teachers, the project will utilize multimedia resources (short video clips and podcasts of lectures and other activities) that can then be shared across the project via a central server, which will be home to our version of iTunes University™ and the project Wiki. Graduate students will make site visits to the schools to ensure that teachers use computer resources effectively. A new server, which has recently been recommended for funding through a competitive grant to Johnson and Mulkey from the Idaho State Board of Education, will host these materials and software, allowing for easy creation and editing of any number of interlinked Web pages using a simplified markup language or a client-side text editor within the browser.

Beginning in August 2012, we will distribute our climate change products to teachers affiliated with the Professional Learning Community provided by the extensive network of the Idaho Digital Learning Academy (IDLA). IDLA is a state-sponsored, accredited, online K-12 virtual school created through the Idaho State Legislature (Title 33, Chapter 55) to provide Idaho students with greater access to a diverse assortment of courses and to qualified faculty. This virtual school was created to address the education needs of Idaho students including traditional, home schooled, at-risk, and gifted students. The IDLA serves students in 98% of Idaho school districts, and had over 9,500 enrollments during the 2008-9 school year.

The IDLA is especially relevant to our goals because in addition to the delivery of online education to students, its Professional Learning Community is designed for teacher professional development. Through the IDLA online workshops for teacher development, we will have flexibility in scheduling workshops for delivery of our climate change TLMs. Through IDLA's links with other regional online education networks, we expect the distance learning plans to find application beyond IDLA and Idaho.

Initiative III. Engaging community and tribal colleges. *The objective of Initiative III is to adapt the products of Initiative I for collaborative training of instructors in regional community colleges and Tribal Colleges and Universities (TCUs)*. The project's cultural specialist on Native peoples (Galindo) will coordinate our activities with TCUs in the region and beyond. We will initially work with Salish Kootenai College, a tribally controlled college chartered in 1977 by the Confederated Salish and Kootenai Tribes located near Pablo, MT. The college is a four-year, accredited land grant institution and a charter member of the American Indian Higher Education Consortium (AIHEC). Salish Kootenai College has agreed to be an initial partner and recipient of our products (commitment documentation available on request). We will also seek to include the United Indian Nations Tribal College in Spokane, WA, which is affiliated with and accredited through Salish Kootenai College. Lewis-Clark State College in Lewiston, ID will be an initial community college partner.

During the summer of 2013, we will convene workshops with instructors from participating community colleges and TCUs. Participants will be recruited through targeted marketing during January 2013, and our graduate student fellows will play a major role in the development of the workshop. Part of the workshop will focus on revising the TLMs for use in the freshman college environment, and we will also work on tailoring the content to match the region associated with each TCU. The NASA Idaho Space Grant at the University of Idaho will co-sponsor these workshops (letter attached). After the initial workshops, we will continue to recruit college and

TCU partners and solicit funding support from NSF, Idaho NASA Space Grant, and participating institutions in order to make this a recurring, annual event.

IV. Impact

The apparent widespread skepticism about anthropogenic climate change in the Intermountain West is an impediment to implementation of effective mitigation and adaptation policies. Providing this population with appropriate scientific understanding is urgent given the impending impacts of climate change on water availability, forest health, and agriculture throughout the region. Our approach to dissemination of climate science to teachers employs two unique features that should result in lasting change in the general understanding of climate change in the Intermountain West. First, the project will emphasize collaboration of teachers with scientists and graduate student fellows in climate science and related fields who have first-hand experience with NASA products and climate science relevant to the regions where teachers and students live. This exposure should result in enhanced understanding of the relationship of the climate system to local and regional ecosystems and economies. Underwritten by peer-reviewed literature, teachers will have greater ability to address persistent myths about climate change and empower students with the tools to address climate change in their communities. Second, the explicit inclusion of place-based resource and cultural issues relevant to the residents and Native peoples of the region will provide students with a more tangible understanding of the role of climate in their lives and livelihood. The impact of this understanding will be compounded, since tribes exert widespread legal and economic influence over the use of natural resources throughout the Intermountain West.

The table at right shows a conservative estimate of the project impact during the funded period. The number of classes is based on the minimum number of instructors (classes) likely to participate, and we assume an average class size of 30 students. The total does not reflect the long-term impact of the ongoing flow of information from scientists to teachers to students after project funding has ended. It is difficult to estimate the widespread impact of Initiative II because of the potential for large-scale dissemination and adoption of the TLMs.

Estimated Project Impact

Phase	Classes (Teachers)	Class size	Total per year	Total by 2014
Initiative I	24	30	720	2160
Initiative II	30	30	900	1800
Initiative III	15	30	450	450
Total students affected during project				4410

V. Project management and execution

Management. Stephen Mulkey (PI), Anne Kern, and Marcos (Ed) Galindo will be responsible for overall management of the project. Mulkey is the former science advisor to the Century Commission for a Sustainable Florida, and the director of the Environmental Science program at the University of Idaho. His academic research has been on the ecology and physiology of tropical forest plants, and he has been a public interpreter of climate science since the early 1990s. Mulkey will lead the science team. Kern is a professional educator with considerable theoretical and practical classroom experience, and she will lead the education team. Galindo holds a doctorate in education and physic and is a member of the Yaqui nation. He will be the cultural outreach lead, will provide input relevant to working with Native students on Initiatives I and II, and will coordinate elements of the project during Initiative III through his contacts with

TCUs in the Intermountain West and nationwide. The three project managers are responsible for annual reports and the application of assessment instruments.

Climate science team. The science team consists of Stephen Mulkey (lead), John Abatzoglou, Karen Humes, Crystal Kolden, Lee Vierling and Von Walden. The science team will meet prior to the start date of the grant and develop a master list of science elements that reflect the seven principles of climate science literacy for inclusion in the TLMs, and hold several meetings during the first year of the project. The team will meet four times during years 2 and 3 to review the science content of the TLMs. Abatzoglou, Kolden and Vierling will provide place-based materials reflecting climate factors such as hydrology and snowpack melt in the Intermountain West. Humes and Kolden will provide materials from MODIS and GISS, and the entire science team will acquire resources from Giovanni and other NASA products. Kolden is both an educator and a specialist in developing remote sensing products for general audiences. All members of the science team will participate as appropriate in the graduate fellow training session and teacher workshops during year 1. Graduate fellow scientists-in-training will assume increasing responsibility for interacting with teachers as the project develops.

Climate education team. The education team consists of Anne Kern (lead), Michael Johnson, James Gregson, Bree Reynolds, and Darin Saul. Kern has extensive classroom experience in schools of the Northwest and Midwest, and she will manage the pedagogical aspects of TLM construction with respect to Initiative I. She will be responsible for pedagogical content of distance learning components for Initiative II. Johnson is a former superintendent of secondary schools and was education specialist at Apple, Inc. He will coordinate all aspects of distance learning and web-based education throughout the project. Gregson has extensive experience in STEM education, and he will critique the PCK aspects of the TLMs. Reynolds is a PhD student at the University of Idaho in the College of Education, who also teaches in the Wellpinit high school and is an adjunct professor of biology at the Spokane Tribal College. She has several years experience in the Wellpinit school district and maintains close contact with the education office of the Spokane tribe. Saul is the University of Idaho Sustainability Director, the Director of the UI Sustainability Center and Affiliate Faculty in Environmental Science at University of Idaho. Prior to working for the University of Idaho, Saul directed the Center for Environmental Education at Washington State University. He has 15 years experience managing all aspects of interdisciplinary projects, including research and outreach efforts directed at K-20, specific technical audiences and the general public.

VI. Partnerships for institutionalizing aspects of the climate change curriculum

The TLMs developed during Initiative I will be created in a form that can be accessed and modified by all users, and they are intended to be effective well beyond the funded period of this proposal. Similarly, the distance learning components of Initiative II can be maintained with minimal institutional effort and expense after they are created and distributed. **IEN** and **IDLA** will be key partners in the distribution and maintenance of the distance learning components.

The professional development provided in Initiative I can be sustained beyond the term of this award in four ways. First, through site visits, we will foster a culture of teachers assisting each other. By providing reliable, persistent web-based resources, the exchange of ideas and revision of TLMs will continue beyond the term of the grant and become part of the regional culture for teaching this subject. Second, through its faculty affiliated with the climate change program at

the University of Idaho, the **Environmental Science Program** will provide science content for revisions of the TLMs and the distance learning components beyond the term of the grant, and periodically provide web-based updates on the latest discoveries in climate science. Third, the University of Idaho **College of Graduate Studies** will provide fellowship support for the fourth year of doctoral studies by graduate fellows associated with this project (letter of commitment attached), allowing them to continue to participate as science ambassadors. In addition, the Environmental Science Program will allocate two fellowships to graduate student support. Finally, this project will deploy a central server with ongoing software and scholarly support for teachers throughout the Intermountain West.

Initiative III will continue beyond the life of the grant to the extent that we are able to obtain financial support for summer workshops and expanded participation of the **Tribal Colleges**. TCUs can provide some in-kind support, such as meeting facilities, but they are unlikely to have the funds to support future meetings. **NASA Idaho Space Grant** at the University of Idaho will support these workshops, provided they have a theme that includes environmental science issues linked to climate change. We note also that the University of Idaho is presently seeking NSF funding to create a center for a graduate training program in STEM for Native students (the ISTEM project). If successful, this program will include meeting facilities, classrooms, and faculty resources that could support the continuation of the yearly workshops of Initiative III.

VII. Relevance

Educational relevance. The program outlined above aligns with two of NASA's three education goals: (1) providing teachers who presently lack the understanding to teach climate change science access to scientists and scientists-in-training; and (2) providing hands on experience with NASA products and educational elements. By enhancing their effectiveness, we expect that these teachers will have improved ability to *engage the minds and imaginations of students in STEM disciplines*, and help to *engage Americans in NASA's mission.* This will most directly affect *Outcome 2*, which is to attract and retain students in STEM disciplines through a progression of educational opportunities. We specifically address Objective 2.1 by focusing on teacher training in the classroom and Objective 2.2 through the participation of IDLA in providing long-duration teacher professional development. Additionally, this project will expand awareness of NASA's mission through its extensive use of NASA products in the TLMs.

Scientific relevance. The project will support scientific relevance by employing a variety of NASA products for development of classroom and online teaching materials. We will strongly emphasize imagery from Earth observation data (MODIS, elements from Giovanni), NASA supported science education materials (ESSEA), and products from NASA funded researchers, including NASA Earth system models (GISS). By using the seven principles of climate science literacy as a basis for curriculum development, we will expand teacher (and student) awareness of science relevant to solar energy, the carbon cycle, Earth energy balance, human impacts on Earth's atmosphere and living systems, and a variety of other Earth Science topics.

VIII. Diversity and the rationale for a focus on Native peoples

Native peoples' resource rights and cultural perspectives on nature will be central to the development of our program. Tribes with sovereign status and specifically delineated treaty rights concerning land-use in the region have many vested interests in any issues concerning

climate change. For example, regional tribes have treaty rights which protect their access to the Salmonid fisheries, which are a keystone resource connected to water quantity and quality, land use, and hydroelectric power generation, and which are in turn linked to other elements of the socioeconomic fabric of the region. Climate change will dramatically alter Native peoples' ways of life over the course of this century, and we feel it essential to bring climate change education to the next generation of Native American leaders. As detailed above, Initiative I of the climate change curriculum project will target two tribal schools and six public schools with significant populations of Native America students from the Spokane, Coeur d'Alene, Nez Perce, and Shoshone-Bannock tribes. The Caldwell school district also serves a significant and growing Hispanic population.

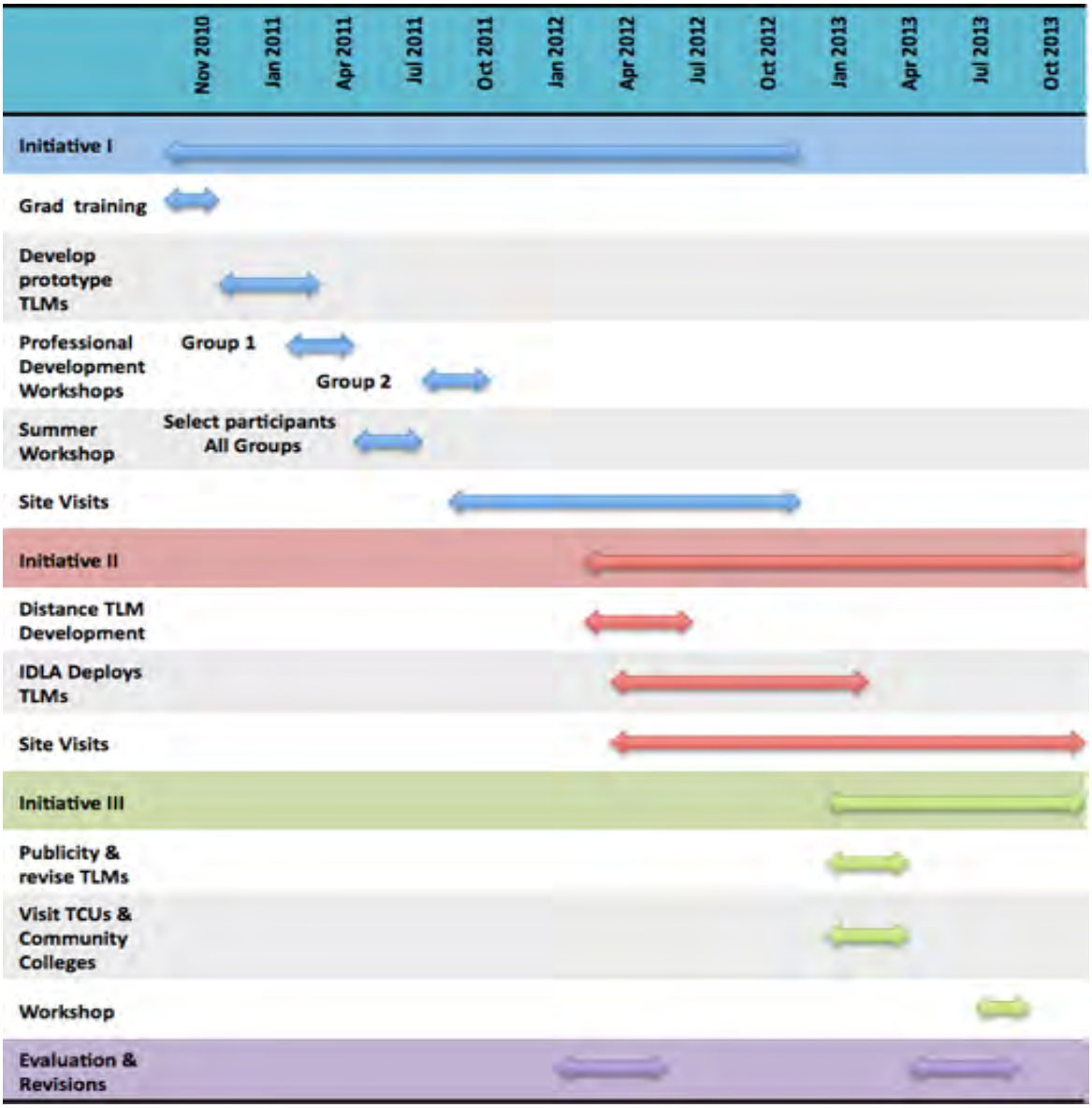
IX. Evidence-based evaluation

Ann Kern, leader of the education team, has formal training in evaluation techniques and will work with Dr. Ed McLain, a contracted professional evaluator and associate professor at the University of Alaska, Anchorage, with over 38 years of experience in education. Our collaborative instructional program is focused on providing the participating teachers with knowledge in climate science and relevant PCK. Thus, our efforts at evaluation will first focus on the teachers themselves. The process of this program will be evaluated formatively, while the effectiveness of this project will determined through a summative evaluation. The formal results of evaluation and actions taken will be reported to NASA during the appropriate quarterly reporting period.

Formative evaluation of Initiative I will involve surveying participating teachers during and after the initial workshop and again at midterm during the academic year 2011-2012. The surveys will focus on levels 1, 2, 3, and 4 of Guskey's five-level evaluation (Guskey, 2000). Teachers will be queried on how the collaborative process has affected their understanding (Level 2) and teaching of climate change science (Level 3). Summative evaluation of Initiative I will involve testing the teachers' knowledge of climate change science with respect to each of the seven principles of climate science literacy (Level 2). This testing will be performed both before and after teachers work with scientists and graduate fellows. Assessment tools and evaluation methods will include selected document reviews, content-based assessments, self-reports, self-assessments, and self-rating surveys, as well as classroom observations (guided by constructed observational checklists) to provide evidence of practice. The science and education teams will collaboratively develop relevant test questions.

Summative assessment of Initiatives II and III will be conducted through online surveys of participating teachers, in which the teachers' knowledge of the seven principles of climate science literacy will be tested. We must also be able to determine whether teacher knowledge has made a difference in student understanding. Accordingly, students will be tested with questions based on the seven principles of climate science literacy before and after working with our TLMs. Surveys comparing before and after student comprehension will be built into the online versions of our TLMs. For all participants, including teachers, students, and project team members, all surveys will be conducted in double-blind fashion so that participants are not identified in the resulting data.

X. Plan of work



XI. External advisory board

The project management team will coordinate yearly electronic meetings with an external advisory board. The board will review our instruction materials, the results of our evaluation surveys, and our processes for teacher professional develop. The following professionals will serve in this capacity:

Donna Hutchinson, PhD, Director IDLA
Christine Meyer, PhD Director of Education, Coeur d'Alene Tribe
Brian Page, EdD, Manager, Strategic Education Relations, Apple, Inc.
Solo Green, Director of Education, Nez Perce Tribe
Sam Olson, EdD, Superintendent Boise School District

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