Beautiful Earth:
Experiencing and Learning Science in a New and Engaging Way

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FINAL REPORT
April 6, 2011 – July 6, 2015
Includes findings from remaining Year 3 and No-Cost Extension Period
Reporting Period: March 26, 2014- July 1, 2015

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Summary

Beautiful Earth (BE), supported by NASA Grant # NNX11AH30G, is an informal education program to inspire and engage students and teachers with NASA Earth science and STEM careers through a unique multi-pronged approach through the heart, head, and hands. It combines three elements: the live multi-media presentation Bella Gaia by Co-I Kenji Williams, which includes NASA imagery of Earth from space, a workshop with a NASA Earth scientist, and hands-on experiments. The program also includes workshops with Native American scientist/educators who provide indigenous perspectives of Earth, and educator development workshops on accessing and utilizing NASA Earth science data.

The BE program is led by Valerie Casasanto, PI, with an experienced team of Co-I's and Collaborators (see table 1 below) and has been successfully run for the past four years. It has reached 22,741 participants including direct interaction (2,741) to students, educators, and family members at 23 locations in collaboration with eight partners (see table 2 below). There were 9 live event locations and 12 Digital Learning Network (DLN) locations in the U.S., and 2 international participants, and indirect interaction (20,000) through DLN web viewers and teen viewers through a partnership with Channel One TV. The attached matrix (Appendix 1) shows all events conducted over the program.

We are pleased to report that the BE program has been **highly successful** as found in external evaluation data and through positive feedback from participants and partners alike. New partners have expressed interest to come onboard. Students have expressed great interest in pursuing Earth science careers and replicating "Beautiful Earth" ideas in their schools. From showing the Beautiful Earth video to their fellow students, to creating action plans for their school to become better environmental stewards, students were inspired by the program.

Scientifically analyzing results from more than 1000 pre- and post-surveys, Action Research & Associates, Inc., the external evaluator, found that ***Beautiful Earth*** **achieved and, in most cases, vastly exceeded all four of its program objectives and target success indicators, including** influencing more than 90% of the participants of the need to act to address global warming **– thereby virtually *doubling* the target rate (50%) of positive audience impact!**

The evaluator found that *Beautiful Earth made a very strongly positive impression on the vast majority (93%) of its audience.* Participants perceived *Beautiful Earth* as a "Big Hit" with more than 9 out of 10 **(**93%) rating *Beautiful Earth* "Highly," i.e. scoring it very favorably at a 7, 8, 9 or 10 overall. The single largest group (48%) rated its *BE* experience at the very top of the scale as a "10."

Analysis of the participants' responses strongly suggests that the *Beautiful Earth Program* was **highly successful in** informing and engaging students and the public about the need to act on global challenges such as global warming. Almost ALL participants (90%) indicated they thought addressing global warming challenges was "Important" to "Very Important." (Table 9) and a full 60% of the participants marked they felt that addressing Global Warming was "Very Important," the highest rating. When asked why they felt that addressing Global Warming is important, 98% were able to provide a good answer. (Appendix 2, Summary Table 2)

Participating in Beautiful Earth also created a dramatic increase and a marked growth of audience interest in The Earth and Earth Sciences. As the audience walked in the door, their interest in knowing more about The Earth was lower than most STEM topics asked about. (See Appendix 2, Table 9) However, after experiencing all components of the Beautiful Earth program, participants' interest in The Earth increased from 3.63/5.0 mean score to 4.22/5.0, <u>a gain of 0.59</u>, <u>the biggest increase of audience interest for any STEM category rated.</u> (Appendix 2, Table 9)

For complete evaluation results, see the final evaluation report in Appendix 2.

Table 1: Beautiful Earth Team Members

Name (alphabetical)	Institution	Role(s)	Elements Leading
Valerie Casasanto	UMBC/GSFC	PI	Hands-On Workshops and Overall Program
Ronan Hallowell	Remedy Arts	Co-I	Native Earth Ways (NEW) Module
Kris Juffer	Action Research & Associates	Consultant	External Program Evaluation
Thorsten Markus	NASA GSFC	Collaborator	Spaceship Earth Scientist (SES) Module
Ana Prados	UMBC/GSFC	Co-I	Spaceship Earth Data (SED) Module
Jim Rock	Indigenous Educational Design	Collaborator	Native Earth Ways (NEW) Module
Kenji Williams	Remedy Arts	Co-I	Bella Gaia Live Show, Planetarium Dome Master, Channel One TV Partnership

Table 2: Beautiful Earth Partners:

Partner	Website
Archbold Biological Station	http://www.archbold-station.org/
BELLA GAIA	http://bellagaia.com
Channel One News	http://channelone.com
Denver Museum of Nature & Science	http://dmns.org
Lamar Bruni Vergara Planetarium (Texas A&M International University)	http://www.tamiu.edu/planetarium/
MOST Museum	http://most.org
NASA Goddard Visitor Center	http://www.nasa.gov/centers/goddard/visitor/home/
Providence Museum of Natural History	http://www.providenceri.com/museum
South Florida State College	http://www.southflorida.edu/

The full grant period (April 6, 2011 – July 6, 2015) was extended from the original three-year length. At the start, the project received reduced funding due to NASA budgetary constraints, and thus had to delay some effort on the program, including pushing one museum event to a later date. In addition, two of the museum partners could not accommodate our dates and requested to have their events occur at a later time. Due to these factors and the fact that original funding to start the program in year one was received late, the PI requested and was granted a no-cost extension of one year (April 5, 2015) in order to complete all remaining milestones on the grant.

This report covers results from the program and work completed under the grant from March 26, 2014 to present, July 1, 2015 (year three and beyond).

Year three and beyond highlights include a Spaceship Earth Data (SED) teacher workshop at the Texas A&M International University (TAMIU) in Laredo, Texas; an event in collaboration with TAMIU's STEM Alliance that included 100 girls and their mothers; events at the Museum of Natural History in Providence, Rhode Island, the Goddard Visitor Center in Greenbelt, Maryland, and Archbold Biological Station in Venus, Florida; a DLN event in collaboration with the GPM mission; and a workshop in Portland, Oregon, with Native American high school students.

The following report will detail these accomplishments and provide a summary of the entire program over the course of the grant.

Accomplishments March 26, 2014 – July 1, 2015 (Year 3 and beyond)

Texas A&M International (TAMIU) STEM Alliance Events

The Beautiful Earth Program took place in collaboration with BE partner Lamar Bruni Vergera Planetarium at the Texas A&M International University (TAMIU) during their STEM Alliance Fair for students and teachers, March 26-29, 2014. The BE programs occurred on Saturday, March 29. One hundred girls (6th, 7th and 9th grade), along with their mothers, fathers, and/or grandparents, participated in the program. The event included a customized Bella Gaia show in the planetarium dome, a scientist discussion with Co-I Dr. Ana Prados (discussing how climate change is already impacting Texas), and a rotation of hands-on experiments on the themes of the Landsat, Aquarius, GPM, and Aura satellites). Girls were matched in pairs (9th grader with a 6th or 7th grader) to perform the hands-on experiments. The Co-I also led a Spaceship Earth Data (SED) teacher professional development training to 19 Hispanic teachers in the afternoon, discussed below.

Left Top: Girls perform GPM Precipitation Tower experiments at TAMIU in Laredo, Texas, March 29, 2014. Right Top and Bottom: Girls perform "Motion in the Oceans" experiments. Left Bottom: Dr. Ana Prados speaks with girls and parents during SED Module.

SED Professional Development Module, March 29, 2014

In collaboration with TAMIU and the STEM Alliance Fair, a SED module was held at TAMIU for teachers and educators. Nineteen (19) 9th through 12th grade Latino teachers participated in the training tailored for the region. The course was taught by Co-I Ana Prados and assisted by PI Valerie Casasanto. After a brief introduction to NASA satellites and how scientists use them to monitor Earth, the teachers participated in hands-on activities where they learned imagery access, visualization and basic analysis that they could use in the classroom. The activities focused on 1) Using the NASA Giovanni web tool to study climate change and 2) Using the NASA Earth Observatory for finding images related to snow cover and other topics. In addition to these NASA web tools and archives, teachers learned how to upload the images to Google Earth. Educators were also introduced to other NASA resources they could use in the classroom, such as NASA Scientific Visualization Studio.

Dr. Prados leading SED Module, March 29, 2015, TAMIU, Laredo, TX

In addition to conversations with the teachers, surveys were used at the completion of the workshop to assess the workshop effectiveness and usefulness of the materials presented for use in teaching Earth science. Program results are discussed later in this report.

Museum of Natural History, Providence, Rhode Island, April 4, 2014

The Beautiful Earth program at the Providence Museum of Natural History featured singer Kristin Hoffmann in the Bella Gaia show, and Dr. Thorsten Markus interacting with the students – about 90 inner city middle schoolers and their teachers. A rotation of hands–on experiments tied to the Landsat, Aquarius, and GPM satellites were held throughout the museum in the context of a "museum quest." The museum provided an additional station, which was staffed by a geologist who showed rocks and minerals.

Left: Kristin Hoffmann sings to students during the Bella Gaia Live show. Right: Thorsten Markus interacts with students during science presentation.

Goddard Visitor Center with the Aura Mission, June 5, 2014

Beautiful Earth teamed with the Aura mission in recognition of Aura's 10th anniversary in orbit. The event was held with the Goddard Visitor Center, a BE partner, for approximately 150 middle and high school students. The Bella Gaia program was customized to incorporate themes from the Aura mission.

Top left: Kristin Hoffmann sings to students during the Bella Gaia Live show. Top right: Student builds a satellite out of Legos. Bottom left: Dr. Bryan Duncan talks with students about the Science on a Sphere. Bottom right: NASA educator Ginger Butcher leads students in an atmospheric chemistry/littleBits experiment.

After the live show, students split into groups and rotated between different stations: "Aura and the Atmosphere on the Science on a Sphere," led by NASA Scientist Dr. Bryan Duncan and co-led by Aura education specialist Stephanie Uz; a Lego satellite-building experiment led by NASA educators Mike Taylor and Kelly Hartford; and an Aura chemistry experiment in which students used Little Bits to build a circuit to measure atmospheric gases, led by Landsat and Aura EPO lead, Ginger Butcher. At the end of the program, participants were given materials related to Earth science, NASA and NASA missions, and sites for more information. In addition, special kits were distributed to the teachers.

View the short video clip on the program created by NASA Goddard's TV studios here: http://beautifulearth.gsfc.nasa.gov/index.php?section=29

Archbold Biological Station / Florida State University, October 16, 2014

Archbold was not listed as an original collaborator on the grant, but became interested in our program and utilized the second slot of partner Denver Museum of Nature & Science. The Beautiful Earth event occurred on October 16th, 2014, with Archbold Biological Station in Venus, Florida, and South Florida State College in Avon Park. Ninety middle school students from Lake Placid Middle School visited Archbold in the morning for a private viewing and participated in hands-on workshops. The college hosted a free public performance in the afternoon as part of its Third Thursday series.

Archbold's Education Coordinator, Dustin Angell customized the event for the local Florida heartland area. The theme was "Connecting NASA's eyes in the sky with Archbold's eyes on the ground."

Williams's Bella Gaia live show included customization such as prescribed fires seen from space, NASA imagery of Florida, and photos and videos of Florida scrub habitat. Following the Bella Gaia Live Show, Dr. Markus talked with students to help them understand the science behind what they were seeing. Following Dr. Markus, Archbold Director Dr. Hilary Swain gave a talk on the coupling of NASA and Archbold research.

Top left: Kenji Williams performs Bella Gaia Live. Top right: Students form a human pixel outside of the Archbold Biological Station, Venus, FL. Bottom left: Students perform "Motion in the Oceans" tennis ball tube experiments. Bottom right: Art students create drawings in real time as Kenji Williams performs at the Florida State College in Avon Park, FL.

Afterwards, students broke up into smaller rotation groups for three hands-on activities: 1) forming a 30x30m human square (the size of a Landsat pixel), 2) "Motion in the Oceans" fluid density experiments in tennis ball tubes (with the addition of hot and cold water option) illustrating ocean currents around Florida, and 3) a hike in the scrub to learn about the local flora and fauna with Dustin Angell.

See the excellent video created by Archbold here: https://vimeo.com/110987002

The afternoon program at the college was an additional event provided by the BE team (not part of the grant). For the first time, art students produced drawings and paintings in real time as Kenji Williams performed Bella Gaia. After the show, Dr. Thorsten Markus provided an interactive session on climate change. After Q&A, all participants viewed students' artwork displayed outside the amphitheatre, further engaged, and collected NASA handouts.

Digital Learning Network (DLN), December 1, 2014

The Beautiful Earth program teamed up with the GPM mission for a 60-minute DLN program which aired live on December 1, 2014. The event focused on extreme weather and featured Dr. Dalia Kirschbaum, GPM satellite mission Applications Scientist. The Bella Gaia program was customized for this event to incorporate themes of "extreme weather" including hurricanes and landslides.

Left: Kenji Williams performs Bella Gaia Live at Goddard's TV Studios, Right: Dr. Dalia Kirschbaum of the GPM mission explained extreme weather from Goddard's TV Studios to students at Doby's Mill Elementary School in Lugoff, South Caroline, via DLN broadcast.

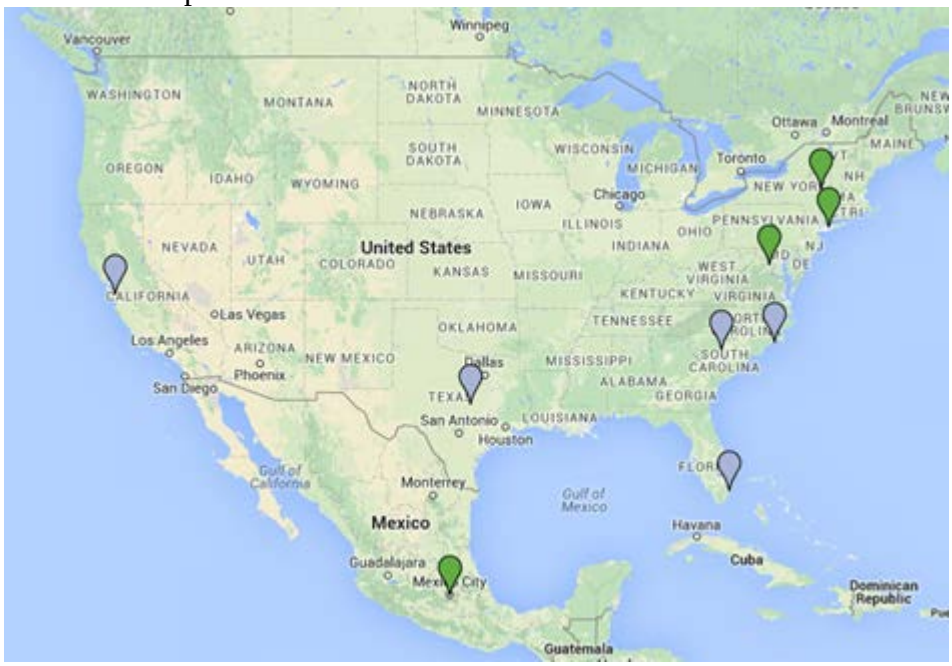
A total of 760 students and teachers viewed the program from 10 schools. Another estimated 1,000 web viewers watched it live via NASA TV. In addition, BE's partnership with Channel One News (a teen television station), reached approximately 6,000 teens in a post-production broadcast. Below is a table of the schools involved. Before the broadcast, GPM education specialist Kristen Weaver had sent the classrooms pre-activities and materials, including lesson plans and activities, videos and other resources related to extreme events (landslides, floods, hurricanes, snowstorms). (See Appendix 5 for complete list.)

Schools participating interactively:
Pleasant Valley Elementary School, Schenectady, NY
Jack Abrams STEM Magnet School, Huntington, NY
Universum Science Museum, Mexico City, Mexico
Liberty Elementary School, Chantilly, VA

Schools that sent questions during the webcast:
Blackford Elementary School, San Jose, CA
Cedar Valley Elementary School, Killeen, TX
GKE/Sabal Palm Elementary School, North Miami Beach, FL
Doby's Mill Elementary School, Lugoff, SC

Others watching:
White Oak Elementary School, Cape Carteret, NC
Secundarshule High School, Uzwil, Uzwil, Switzerland (one of GPM's Master Teachers)

See below map below for locations.



Map of DLN participant locations. Key: green – participating interactively; blue – watched via the webcast

The program was organized into several segments: hurricanes, floods and landslides, and snow events. It started with an introduction by Dr. Dalia Kirschbaum, then a live performance from Kenji Williams. Each segment was followed by a Q&A with Dr. Kirschbaum. The full webcast is archived on the GSFC SVS website and can be viewed/downloaded here: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10276. The full program, or just a particular segment, may be downloaded. The segments can be played in classrooms to introduce these NASA research areas into the classroom.

This DLN program was also piped into the Goddard Visitor Center during "Take your children to work" day, so kids and parents could view the program. The Visitor Center also featured hands-on activities and the SOS movie Water Falls for the participants.

NEW Tribal Workshop, Dec. 6-7, 2014, Portland, OR

The two-day workshop led by Co-I Dr. Ronan Hallowell titled "How We're All Connected: Native America & Western Scientific Perspectives" addressed three essential questions:

1) What can Western scientists learn from Native American wisdom about respecting life on Earth? 2) How can NASA/Western Earth and life sciences enhance the well-being of Native American communities? 3) How can Native American students gain access to STEM education that is relevant to their lives?

The workshop took place December 6 & 7, 2014, at the Ant Farm Community Center in Sandy, Oregon, near Portland. This special version of the NEW workshop featured Native American educators, NASA scientists, and a Stanford University School of Medicine biochemistry professor leading students from the Chemawa Indian School through a workshop. The event used singing, drumming and storytelling to discuss how Western scientists can learn to listen to Native wisdom so that their work can be of greater benefit to Native communities, and enhance the well being of Earth's life-systems for future generations. The Saturday morning portion focused on the elders' teachings, and the afternoon and Sunday morning portions were dedicated to working with students to integrate the morning lesson. Native American educators and Beautiful Earth collaborators Mr. Jim Rock (Dakota) and Dr. Roxanne Gould (Odawa/Ojibwe) contextualized Earth science insights in context of Native traditions regarding Earth stewardship. NASA Beautiful Earth collaborator Dr. Thorsten Markus provided insights into NASA Earth science through an interactive presentation. In addition to being active participants in the singing and storytelling, students had the opportunity to interact and do a hands-on experiment with NASA personnel (Dr. Thorsten Markus and Valerie Casasanto) and learn about NASA and STEM careers that can make positive contributions to environmental sustainability.

Fourteen Chemawa Indian School students (11th and 12th grades) from five tribal nations across the Western United States and Alaska came from their boarding school in Salem, Oregon, to the Ant Farm Community Center outside of Portland. In addition to providing the workshop space, Ant Farm also provided camping accommodations on Saturday night for the students. Students indicated in the surveys and in conversations that they really appreciated going off-site and being able camp overnight. The Chemawa Indian School is the oldest Native American boarding school west of the Mississippi and is run by the Federal Bureau of Indian Education.

Portland-based Native American (Akimel O'odham/Pima) elder Rod McAffee, 83, and Dr. Ron W. Davis, an eminent Stanford University biochemistry and genetics professor, were the senior teachers for the workshop. Rod and Ron have known each other for more than 20 years in the context of Native American Sun Dance and sweat lodge ceremonies in the Pacific Northwest. Elders are held in high esteem in Native American cultures and this was a unique opportunity since the western scientist is well versed in Native ways (which is not all that common). Three students in the group were from the same tribal nation as McAffee, and they were particularly happy to meet him and hear him speak their language.

The executive director of the Ant Farm Community center, Two Foxes Singing, was the crucial link with the Chemawa Indian School. His organization had been working with students already, and he negotiated the fairly complex administrative arrangements required by a federally run boarding school. In a follow-up email between the workshop organizers after the event he shared his positive reflections: "The experience was invaluable. I have seen many of our students receive support through the therapy world. I am very excited to see them receive support through identification of their own motivation in change. To watch them become excited about being better people while pursuing dreams of science and study was amazing. It was encouraging for the NASA team to come to me following the event asking to pursue a stronger partnership. It was equally encouraging to have respected Native teachers (in ways of the people and in science) also ask to continue a partnership."

Left: Group of facilitators including (back row) Two Foxes Singing, Dr. Thorsten Markus, Dr. Ronan Hallowell, Valerie Casasanto, Dr. Ron W. Davis, Dr. Roxanne Gould (Odawa/Ojibwe), Mr. Jim Rock (Dakota), front row Native Elder Rod McAfee (Akimel O'odham), and Linda Neale. Right: Dr. Thorsten Markus interacts with Chemawa students as he explains the global thermohaline circulation system.

Left: Angela Noah, Chemawa Indian School, with Dr. Ron W. Davis, Stanford Univ. School of Medicine
Right: Chemawa students perform "Motion in the Oceans" experiment.

After every BE event, a "lessons-learned" meeting was held to gather data to improve the program for each future event.

More Accomplishments -- Conferences/Workshops/Other Events

- In 2011, an educator guide was written by Nancy Volk, Educator at the MOST Museum - Milton J. Rubenstein Museum of Science & Technology. The educator guide provides supplementary educational activities as a follow-on to the Beautiful Earth Program with the Onondaga Nation School at the MOST museum in October 2011. See Appendix 7 or click here to download guide.
- In October 2012, PI Valerie Casasanto with Co-I's presented and published a paper at the 63rd International Astronautical Congress (IAC) entitled "Beautiful Earth: Inspiring and Engaging Students and Families through Music, Art, and Science."
- In December 2014, PI attended SMD EPO community meetings and conference sessions at the Fall AGU Meeting in San Francisco, CA.
- April 24, 2014, Take your child to work day at the Goddard Visitor Center: PI performed "Motion in the Oceans" fluid density hands-on experiments for approximately 200 children and their parents.
- April 2015 Take your child to work day at the Goddard Visitor Center: GSFC educators performed "Motion in the Oceans" fluid density hands-on experiments for approximately 200 children and their parents.
- Sunday experiment on Earth Sciences 2015 at the Goddard Visitor Center GSFC educators performed "Motion in the Oceans" for approximately 150 children and family members.

All of the above-mentioned items were not funded by the EPOESS grant.

Summary and findings of Beautiful Earth Program by Module

Spaceship Earth Scientist (SES) Module

The goal of the SES module was to explain to the students what the visualizations and videos presented by the multi-media performance actually mean and how they are generated. This helps lead to a deeper understanding of the science being presented. The SES module was led by Dr. Thorsten Markus. Dr. Markus presented at 80 percent of the locations. Originally, the idea was to have a scientist specialist for each program theme. It turned out that the lessons learned were applied and Dr. Markus' interaction with students and presentations became more and more effective.

The format of the science talk has changed significantly over the course of the project, applying lessons learned from each previous event. During the first Beautiful Earth event, the science talk followed right after the 30-minute multi-media performance in the Imax theatre. While the large screen may make science visualization particularly impressive it became clear that having the students sit any longer, especially for "a science talk," was not ideal. Therefore, in the following events the students were split up into groups, and while some groups did the hands-on experiments other interacted with the scientist. The format changed from talk to interaction, from unidirectional to bidirectional. Smaller groups encouraged and generated more questions from students. At times these science talks went long just because students continued to ask questions. Furthermore, some science content was replaced with pictures, videos and stories (with wildlife pictures) from his trips to Antarctica. The description of personnel experiences greatly increased the interest and engagement of the students. Overall, the module changed from "science talk" to "talk with a scientist."

Spaceship Earth Data (SED) Module

The purpose of the SED Module was to bring actual Earth science data to educators and give them guidance on how to access it. SED is led by Dr. Ana Prados, who also leads NASA's ARSET program. Three SED modules were held for teachers and educators over the course of the grant. Surveys were used at the completion of each workshop to assess the workshop effectiveness and utility of the materials presented for use in teaching Earth science. During all three workshops, teachers were first provided with an overview of NASA Earth science and remote sensing. The rest of the workshop consisted of a mixture of lectures and hands-on activities where educators learned how to access and use NASA web tools and archives, and how to upload images to Google Earth. They were also introduced to additional NASA resources that they could use in the classroom.

The first module was a half-day workshop at NASA Goddard Space Flight Center on March 27, 2012. Eleven educators from middle school through high school attended the event, including one educator from Goddard's Visitor Center. Teachers participated in hands-on activities where they learned imagery access, visualization and basic analysis appropriate for use in the classroom. The surveys indicated that there was an appreciable increase in their level of knowledge of NASA resources after the training. The average rating of the workshop, the lectures, and the materials was between 4 and 5, out of a total of 5. The teachers particularly appreciated the opportunity for the hands-on

component and 7 out of 11 teachers indicated that they would be using the NASA resources and tools they learned in the classroom.

The second module was a workshop coordinated by BE partner the MOST museum and held at the State University of New York College of Environmental Science and Forestry (SUNY-ESF) in Syracuse, New York, on August 6th, 2013. Relative to the other trainings, there was a greater fraction of high school teachers, and they were able to benefit from a moderately more advanced module that included hands-on activities using Giovanni, an analysis and visualization tool used in Earth science research and education worldwide. In this case, teachers analyzed carbon dioxide maps and time series. A total of 22 participants attended including high school teachers and College professors from SUNY's ESF. During the lunch break, a discussion was held with the teachers to gather feedback. Teachers suggested posting the materials on the website ahead of time, providing more definitions for remote sensing terminology, and a more in-depth introduction to climate change. They also suggested incorporating into the workshop a session for teachers to gather and develop a lesson plan based on NASA resources. The overall survey findings revealed that participants' knowledge of the material before the workshop was a 1.9 on a 5 point scale. After the workshop their knowledge increased to 4.3/5. Overall rating of the training was 4.5/5.

The third module was a half-day workshop held in Laredo, Texas, at the Texas A&M University on March 29, 2014. The course highlighted use of NASA's Earth Observatory and Giovanni. The overall survey findings revealed that teachers found the course interesting and applicable to their classroom work. Nearly all rated the usefulness of the NASA Earth Observatory and Google Earth as either 4/5 or 5/5 and Giovanni as a 3/5 to 5/5 (1=not useful; 5=very useful). About 80 percent of the teachers rated the overall workshop as a 5/5. All 19 teacher participants were Hispanic and taught high school level.

Native Earth Ways (NEW) Module

The Native Earth Ways module served as an opportunity for outreach to an underserved population. It was also a way for Earth scientists and students of Earth science to learn from Native American traditions that have a long history of stewardship relationships with natural environments. Mr. Jim Rock, a member of the Dakota Nation who also taught high school science for 30 years, served as a consultant to the project. He provided advice on intercultural communication during planning meetings, conference calls and lessons learned follow-ups. He also presented at five events and co-facilitated at the culminating NEW workshop for Chemawa Indian School students in December 2014.

In the first two years of the project, aside from Mr. Rock's presentations, such as the DLN program, the NEW module was integrated with the SES performance and presentation through a collaboration with the Syracuse Museum of Science and Technology (MOST). In year one our inaugural event was for 150 students and families from the Onondaga Nation School. For that event, Co-I Ronan Hallowell, in collaboration with Dustin Angell (MOST), worked with Onondaga Nation School teacher and cultural leader Freida Jacques to design the event to address needs and interests of the Onondaga Nation community. This included a focus on the restoration of Onondaga Lake as well has having the event start with a version of the Haudenosaunee Thanksgiving Address delivered in Oneida (an endangered Haudenosaunee language).

In year two, with the MOST museum, we collaborated with Neal Powless, a member of the Onondaga Nation and Assistant Director- Native Student Program, Academic Affairs at Syracuse University. Together, we brought 15 Native American students from Syracuse University to facilitate environmental discussion circles with students after the SES presentation. The event also kicked off with a version of the Haudenosaunee Thanksgiving Address, delivered by Chief Jake Edwards in the Onondaga language. Also in year two, Co-I Ronan Hallowell traveled to meet in person for two days with Mr. Jim Rock to discuss cross-cultural communication strategies. They also record a video interview in which Mr. Rock discussed his decades of experience learning and teaching science, while also fully participating in his Dakota tribal culture and sharing with other indigenous cultures in North and South America.

The year three culminating event for the NEW module took place December 6-7, 2014 at the Ant Farm Community Center in Sandy, Oregon, near Portland. The two-day workshop titled "How We're All Connected: Native American & Western Scientific Perspectives" explored Native American wisdom and Earth science perspectives on current planetary environmental issues. Fourteen Native American high school students from the Chemawa Indian School in Salem, Oregon, were bussed from their school site to Ant Farm and were provided overnight camping near Mt. Hood. Co-I Ronan Hallowell brought together a local Native American elder (Rod McAffee-Akimel O'odham) and a world famous Stanford geneticist (Dr. Ron Davis) who is familiar with Native traditions to discuss more effective cross-cultural communication. Native educators and Beautiful Earth collaborators Dr. Roxanne Gould and Mr. Jim Rock provided further context for Native wisdom/western science dialogue. NASA personnel Dr. Thorsten Markus and Valerie Casasanto shared NASA Earth science insights about the planet with students. Students were actively involved in the workshop through singing, drumming, discussion, camping, and a hands-on ocean salinity experiment.

On the post-workshop survey, 8 of 14 students indicated that Dr. Thorsten Markus' presentation on ocean currents was their favorite part of the workshop. After the workshop, one student followed up with PI Valerie Casasanto by email and phone to ask if she could share what she had learned at her school's health fair, with the hopes of starting a larger project inspired by Beautiful Earth. Co-Investigator Ronan Hallowell received multiple follow up emails from a 12th grader who intends to stay in touch with Dr. Hallowell to receive mentoring advice. This student was accepted to Western Washington University and plans to study Environmental Engineering.

Overall, students appreciated the respectful resonance between indigenous and Earth science perspectives on the interconnectedness of Earth's life systems. One student said in the survey, "I really enjoyed the drumming and seeing the connection between indigenous ways of knowing and western science!" Another young woman "liked that I met an elder from my tribe because he speaks the original O'odham language." Overall, the response from the Chemawa Indian School students was very positive. If funding were available, Chemawa would be an excellent school to pursue future projects with.

Digital Learning Network (DLN) Events

Over the course of the grant, three live distance events were held on different themes. In year one, Kenji Williams customized the show to include science areas relative to polar regions and indigenous perspectives on climate change. Mr. Jim Rock (BE Collaborator and Dakota Native) and Dr. Thorsten Markus (BE Collaborator and Chief, Cryospheric Sciences) interacted with participants. In year two, the show was customized to discuss climate change and research areas of Dr. Claire Parkinson, who presented her work and interacted with students. In year three, the program was customized to include themes from the GPM mission, such as extreme weather. Dr. Dalia Kirschbaum interacted with students. The full webcasts and smaller clips are available for download/viewing at these links:

DLN Earth Day 2012, April 18, 2012: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10993

DLN Earth Day 2013, April 22, 2013: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11258

DLN with GPM, December 1, 2014 http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10276

Left: Mr. Jim Rock (Dakota) with Erin McKinley, DLN Host. Right: Kenji Williams performs Bella Gaia in front of a green screen. Both photos from Beautiful Earth DLN Event 2012.

Hands-On Experiments

Over the course of the program, hands-on activities were incorporated into each program – customized for each site's theme and/or locale. Landsat activities (walk on a Landsat Tile and find local landmarks, compare and contrast Landsat data from the 80's with data from the present), Aura activities (Build a satellite out of Legos, littleBits build a sensor to measure the atmosphere),

The single most successful and widely used experiment across a majority of the sites was the "Motion in the Oceans" hands-on experiment to investigate fluid densities. The experiment was provided to the BE team by Collaborator, Jim Rock, and further refined and developed. Children from

4th grade to adults alike, enjoyed performing these experiments mixing fluids in recycled tennis ball tubes. The experiment has been so successful, many NASA museum partners, and other NASA educators, have replicated the experiments at their sites for a variety of educational events. In years 2 and beyond, the stunning NASA SVS visualization "Thermohaline Circulation: The Great Ocean Conveyor Belt": http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=3658 was included. This was an excellent refinement of the lesson to introduce the concept of fluid densities and ocean movement prior to students performing the experiments.

The experiment passed the NASA SMD Product Review with some minor modifications required. PI will complete the modifications and re-submit and have it posted on NASAwavelength.org and the Beautiful Earth Website.

Channel One TV Partnership

A partnership was formed with Channel One News - http://www.channelone.com/ an education TV network that reaches 6000 high schools/6million students across the country. The DLN program was edited and cut down to 15-20min – and customized so as to be used in a classroom setting by teachers. Channel One received the customized content and uploaded it to their servers, where teachers could download and playback the video for their students. The Beautiful Earth DLN videos were so popular, that Channel One left it on their servers for 3 months (3x longer than normal).

Dome Master for Museum Partners

The Bella Gaia show was delivered to Museums as a 4k dome master – a format playable in Fulldome digital Planetariums in 4096x4096 resolution. These museums were Denver Museum of Nature & Science, Texas A&M University, and the Museum of Natural Science Rhode Island. As a leave-behind asset for Museums to play back, a shorter dome master is available for download and playback upon request, as seen on the Bella Gaia website: http://www.bellagaia.com/fulldome.html

List of Appendices:

Appendix 1 – Table of Events

Appendix 2 – Final Evaluation Report by Action Research and Associates, Inc.

Appendix 3 – "Motion in the Oceans" Experiment Procedure

Appendix 4 – Sample Program Agenda (Goddard Visitor Center)

Appendix 5 – GPM DLN Pre-classroom activities

Appendix 6 – List of Beautiful Earth Video Links and web links

Appendix 7 – MOST Museum Beautiful Earth Educator Guide

Appendix 6 - List of Beautiful Earth Video Links

Digital Learning Network (DLN) Broadcasts:

DLN Earth Day 2012: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10993

DLN Earth Day 2013: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11258

DLN with GPM, December 1, 2014 http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10276

Other Videos created:

Archbold Biological Station Event, October 16, 2014: https://vimeo.com/110987002

Goddard Visitor Center event, June 5, 2014: http://beautifulearth.gsfc.nasa.gov/index.php?section=29

Important Web Links:

http://beautifulearth.gsfc.nasa.gov/

www.bellagaia.com