

Ways of Knowing from Father Sky: Native and Western Research Protocols – From Paradox to Collaboration

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Introduction

Humans across all cultures have venerated, observed, and studied the Sun, the Moon, the planets and the stars of Father Sky for thousands of years. Ancient peoples were keen observers of the skies, and astronomies were developed that featured complex interdependencies and holistic ways of knowing. Great civilizations such as the Maya of Mesoamerica developed complex astronomical tracking systems and detailed calendars spanning many thousands of years. Astronomical knowledge was reflected in the massive architectural monuments seen in México, Guatemala, Honduras, and other areas of Central America. The Maya had a complex system of mathematics and geometry that included the use of ‘zero.’ They had an elaborate writing system that kept track of thousands of years of ancestral and celestial history. They created ancient observatories to measure, track, and predict the motions of the planets, the Sun, the Moon and the stars. They observed the motions of celestial bodies in the sky for the purpose of planning and celebrating key dates in their ritual calendar including for purposes of agriculture. Many of these astronomical traditions are still practiced today by the Maya of the Yucatán peninsula, Southern states in México, and extensive areas of Guatemala and Honduras. Traditional farming communities today time the cultivation of corn and other crops by observing the movements of the Sun and the stars.

Similarly, indigenous peoples of the Southwestern United States continue to incorporate knowledge of the stars in daily living, using keen observations of the motions of the Sun and stars for planting and ceremony. Peoples such as the Navajo and Pueblo Indians utilize astronomical practices incorporating rich and complex traditional knowledge of the Sun, Moon and stars. These practices are reflected in ancient and contemporary architecture such as the present-day Navajo hogans, Pueblo kivas, as well as the ancient Great Houses found in Chaco Canyon, New Mexico, and many other Ancestral Pueblo sites in other southwestern states including Arizona, Colorado, and Utah. The Anasazi, or more recently termed Ancestral Pueblo people, developed a complex system of astronomical knowledge that served as a foundation for their sophisticated and intricate architectural infrastructure. Great cities were built over centuries that feature remarkable alignments with the cycles of the Sun and Moon. In fact, scattered throughout what is called the “Four Corners” area of the southwestern United States, many ancient cities that thrived more than a thousand years ago, including Chaco Canyon, Hovenweep, Mesa Verde, Yellow Jacket, Canyon de Chelly, etc., feature stellar as well as Sun and Moon connections.

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Astronomy traditions continue today through both indigenous and Western science. Scientists from NASA and other institutions, as well as indigenous astronomers all over the world, continue to gather knowledge of the Sun, our solar system, and the stars beyond. Western research relies heavily on technologies and instrumentation that enhances the human ability of observation combined with a mathematical theoretical framework. Indigenous peoples from around the world gather and preserve astronomy knowledge through oral traditions, ceremony, and careful observations, in relationship with the land and the sky. These traditions are strong today. Quechua speaking farmers in drought-prone regions of South America still use their knowledge of weather-related visibility of stars to time their planting and harvesting. Pueblo and Navajo peoples in the Southwestern United States continue to make careful observations of the Sun to mark seasonal change, time ceremonies, and adjust planting cycles. These holistic practices are carried out in deep relationship with the land and the sky.

By contrast, western technologies have contributed towards the fragmentation of science into focused disciplines. While such specificity assisted by technology allows for detailed studies, it also distances human beings from nature. When we consider the Sun-Earth Connection, satellites in space are yielding results telling us that the Sun, our nearest star, is responsible for space weather effects through a constant stream of charged particles that flow from the Sun called the solar wind. Effects on Earth include the aurora or Northern and Southern lights, and influences on today's technology including satellite communications and electricity power grids. The safety of humans in space also depends on our ability to predict solar storms that can be harmful and potentially lethal to astronauts orbiting the Earth. Technology has allowed us to increase our understanding of the Sun over the past 100 years, however, it is only relatively recently that we recognize that knowledge of the Sun and how it affects weather, long term climate change, global warming, etc. is critical to protecting complex and fragile ecosystems on Earth. Indigenous knowledge systems have recognized subtle and deep interdependencies between the Sun and the Earth for thousands of years, while western science has fragmented knowledge to the point that interdependencies are not easily recognized.

Western astrophysics also focuses on studying the stars other than the Sun, beyond our Solar System. Astrophysics recognizes that the Sun is a star and stars are suns. In western and indigenous astronomy, one of the most studied and revered star clusters in the sky is what western scientists call the Pleiades and Navajo astronomers call Dilyehe. The Pleiades are seen in the night sky throughout most of the world. Observations of the Pleiades (during the time when the cluster first appears above the eastern horizon before sunrise, or disappears below in the western horizon after sunset) have been done by indigenous peoples over thousands of years to time planting and harvesting seasons as well as ceremonies.

A fundamental relationship between stars like the Pleiades and human beings on Earth is the knowledge that the organic material in our bodies was created in stars. This knowledge is held by indigenous knowledge holders as well as western astronomers. The Pleiades are venerated by indigenous peoples universally, who nurture a deep relationship with this sacred cluster. For example, Cherokee and Hawaiian cosmologies speak of the

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peoples' origins from the stars, specifically the Pleiades. Navajo tradition mentions consciousness that emanates from the stars. Other Native American tribes hold knowledge of origins from the Milky Way as well as from other indigenous constellations.

Western scientists have strongly focused on the physical properties of stars. Using the technique of spectroscopy (the detailed analysis of light from a star by dispersing white light's rainbow of colors through a diffraction grating) western scientists study the chemical composition of the gaseous material in stars and in between the stars. By combining the observations of light from the stars and the material between them with our theoretical knowledge of how stars age and evolve, scientists have found that chemical elements with atomic number heavier than helium are created through the process of nucleo-synthesis inside stars. An example of nucleo-synthesis is the merging of four hydrogen atoms inside our Sun to create one Helium atom plus large amounts of energy that fuel the brilliance of the Sun. Since the Sun has so much hydrogen in its core under tremendous pressure and temperature, nuclear fusion reactions have been occurring for the past five billion years since the formation of the solar system, and may continue to go on for the next five billion years. At that future time, the Sun may continue through an aging and evolution process forming heavier and heavier elements (Helium into Carbon, Carbon into Nitrogen, Oxygen, etc.). Stars in the Pleiades are similar to the Sun but with more material – they are more massive. In several million years, the brightest stars in the Pleiades may undergo similar element synthesis processes, and as a stage in their evolution, may explode into space releasing the chemical elements into the inter-stellar material. New stars and planets may form out of this 'recycled' material enriched in heavier elements. Eventually life may develop on these planets. On Earth, organic matter, what constitutes all living beings, is made from elements created in stars that exploded into the inters-stellar medium, providing the raw material for the Sun and solar system to form. Thus, the findings of western science are consistent with the knowledge held by native astronomers, namely, that humans come from the stars. Humans are, indeed, star dust. Knowledge about how life originated on Earth is still a mystery to western science, but we know that the chemical elements of life come from stars.

The strong and rich astronomical traditions that still thrive in indigenous communities throughout the world can provide a framework for indigenous peoples to integrate western astronomical knowledge with worldviews that are grounded in thousands of years of tradition. In a society that relies increasingly in the use of science and technology, we recognize the potential benefits to indigenous youth that can be afforded by authentic participation in careers in science, mathematics, and technology. We also emphasize the benefits that can be provided to the western scientific enterprise through an indigenous science paradigm that is more holistic and utilizes integrated, systems-based research approaches. We believe that these benefits for our human society, and especially for our Earth, can be animated through authentic collaborations between native and western scholars. There is a need to re-awaken indigenous consciousness in all humans. What better way to do so than through astronomy and our yearning to understand and honor our place in the Universe!

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Indigenous and Western Research Protocols

Western scientists from NASA and other institutions conduct astronomy research using scientific methods and technologies couched in terms of mathematical and mechanistic theories that are founded on well-developed hypothetical, deductive and experimental methodologies. Indigenous astronomy incorporates many, but not all, of these elements, and it is embedded in a larger social and human context which is often lacking in western science. Ancestral indigenous knowledge of astronomy is founded on careful and systematic observations of nature's cycles, combined with societal arrangements that hold, develop, and apply knowledge for the benefit of the community. Indigenous astronomical knowledge is attuned to the complex interdependencies between humans and the natural order.

There are differences between doing native research within a community and doing western university-based research. Teaching and learning about Navajo Astronomy is a considerably different process than studying Babylonian and Greek mythology or conducting western space science research. The very time and space in which knowledge can be transmitted is different when one talks about Navajo ways of knowing in comparison to academic inquiry and western scientific knowledge transmission. Navajo star knowledge has been passed down for countless generations through oral communication and traditional protocol. Unlike conventional academic learning, which comes primarily from books in libraries and the Internet, native star knowledge comes primarily through oral stories, song, ceremony, field work, and interviews, which can take years to verify and/or validate due to specific social protocol of knowledge transmission and to the somewhat esoteric nature of the knowledge. Pieces of stories can be held by different families or clans, with variations in interpretation acknowledged. There is often no one correct way to tell the star stories, since each version holds its own integrity and lineage, sometimes related to different Navajo healing ways.

In the indigenous paradigm, transmission of knowledge occurs in relationship with the community that is affected by such knowledge. Traditional knowledge comes from elders and knowledge holders, not printed books. Validation of knowledge and knowledge holders is done through community rather than college professors. Thus, when we talk about transmission of native knowledge, such knowledge is inextricably connected with the language, songs, and ceremonies, where ancient traditional knowledge resides, and has been told and sung, with unchanging formats, for thousands of years.

The levels of knowledge transmission among many indigenous tribes, including the Navajo, are important. For example, the teaching and materials that we share with public audiences do not include ceremonial teachings, as we leave such teachings in the realm of the medicine people. Levels of knowledge transmission in native culture reflect the checks and balances (reciprocal relationship and responsibility) regarding who holds and shares this knowledge, so that potentially powerful knowledge is not abused by the community. In western science, curiosity and ability (expertise) are both necessary and

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sufficient criteria for seeking knowledge. In the native paradigm, a desire to know and ability (expertise) are helpful, but not sufficient criteria for the search of knowledge. Native researchers may be asked by elders “Why do you want to know?” Reciprocal relationship, responsibility and obligation to community are integral to the quest for knowledge. These considerations are seldom found in western research protocols.

Our Collaboration

Native scholars with deep knowledge of traditional and observational astronomy from the Indigenous Education Institute (IEI) are collaborating with western scientists from the United States National Aeronautics and Space Administration (NASA), as well as other institutions that include Universities (UC Berkeley), and other science museum and media developer partners such as the Exploratorium and Ideum. IEI is a non-profit corporation that is composed of, and directed by, indigenous people from various tribes in the United States, and an International Advisory Council including native peoples from various countries. NASA is the governmental space agency in the United States. UC Berkeley is a public western University, and Exploratorium and Ideum are institutions whose goals are to attract and engage the general public in science, enhancing the public’s scientific literacy through approaches that integrate art, human perception, and culture. Our unique research and development astronomy-based collaboration has been ongoing for the past eight years, including partnerships between IEI with several NASA entities. The collaboration has sustained a successful track record because it upholds the integrity of both western and indigenous astronomy knowledge and research protocols, and because it honors the native languages. Through working together, we have been able to identify common elements from seemingly paradoxical frameworks and work towards an authentic and sustained collaboration.

Indigenous knowledge systems are highly sophisticated and have the potential to contribute to the advancement of science. Despite this potential, Native Americans are woefully under-represented in careers in science and other related fields such as engineering, and mathematics (AIP 2005). For example, in the United States less than 1% of all scientists and engineers are Native American. One of the contributing factors to such dismal statistics may be the fact that programs designed to engage Native Americans in science have not typically acknowledged that science is culturally dependent: namely, that indigenous cultures have over millennia developed their own technology, mathematics, science, and ways of knowing that are holistic and interconnected. Western science-based programs designed to reach Native audiences tend to include Native content as a cultural perspective or myth, and not as observation-based science.

Full appreciation of native science requires the recognition that indigenous knowledge systems stand on their own right, and that such knowledge and paradigms have can enhance the process of western science. Increasingly, scientific projects are taking into account indigenous knowledge. For example, in a recent article (Ludwin *et. al.* 2005) western scientists collaborating with Native elders from the Coast Salish people of the Northwestern United States were able to identify dozens of previously unknown small earthquake faults in the Seattle area tied to a much larger fault line, based on native

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stories of the appearance of a two-headed serpent spirit (connected with the quaking Earth) at these locales. Farmers in drought-prone regions of Andean South America have historically made observations of changes in the apparent brightness of the Pleiades around the time of the southern winter solstice in order to forecast variation in summer rainfall and time their planting and harvesting accordingly. Recently, western scientists used satellite data to verify that the variability in the Pleiades is correlated with El Niño climatic patterns that affect yearly rainfall patterns (Orlove, Chiang, and Cane 2000). These and many other examples can help make the native science paradigm become visible to native and non-native students and scholars.

Western science is increasingly recognizing that integrative and systems approaches to science are essential for a deep understanding of nature. It is at the intersection of astrophysics and particle physics, for example, that new insights and new challenges about what we still don't understand about the origin of the Universe become visible. Integrative and holistic approaches to science that acknowledge the influence of culture on western science can broaden access to scientific disciplines including physics, chemistry, geophysics, and astronomy – disciplines where there is very little diversity in the practitioner pool (Aikenhead 2005). Innovative ways of looking at western knowledge, for example, the “Chemical Galaxy” representation of the periodic table of the elements (Stewart 2005) can make such knowledge more accessible to large numbers of the population. It is our belief that native ways of knowing, in which understanding of nature fully engages human beings as active participants in the process of learning, in which the use of our senses is valued as much as the use of our intellect, can provide enhanced access to western and native science to *all* people. We have thus collaborated closely in an effort to juxtapose native and western knowledge of astronomy across time and culture.

Ancient Observatories – Timeless Knowledge Project

Over the past six years, the NASA's Sun-Earth Connection Education Forum has sponsored and coordinated education and public outreach events to highlight NASA's Sun-Earth Connection research and discoveries. Our strategy involves using celestial events, such as total solar eclipses and the Transit of Venus, as well as *Sun-Earth Day* during the March Equinox, to engage primary and secondary schools and the general public in space science activities, demonstrations, and interactions with space scientists. Our project, “Ancient Observatories – Timeless Knowledge” includes several partners, namely, IEI, NASA, Exploratorium, Ideum, NASA Connect, and Sun-Earth Connection satellite missions. We produce comprehensive, theme-based websites, webcasts, other multi-media, and print resources for use by school and informal educators internationally. We provide training and professional development to school educators, museum personnel, amateur astronomers, Girl Scout leaders, etc., who implement their own outreach programs taking advantage of our resources. A coordinated approach promotes multiple programs occurring under a common theme. The *Ancient Observatories – Timeless Knowledge* theme for 2005 featured solar alignments with indigenous structures that mark the equinoxes and/or solstices. For this theme, we developed the following key messages:

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Key messages: Ancient Observatories Project

- The Sun is a dynamic, magnetic star that impacts the Earth and other planets in our solar system
- Understanding the mysteries of the Sun has been a primary motivator for Sun watchers over time
- Human beings use technology (past, present, and future) to understand the Sun and the Universe beyond
- Light has always provided a means of investigating the Universe
- Human beings from diverse cultures have viewed the Sun as the source of life
- Stewardship of these sacred sites is our collective responsibility

To support these key messages, we produced webcasts and video programming that was shared with formal and informal education audiences internationally. The programs featured several sites including: Chaco Canyon and Hovenweep in the United States and Chichén Itzá in Mexico. NASA Sun-Earth Connections research was presented in a human and cultural context through live bilingual webcasts and video broadcasts from Chichén Itzá, Yucatán, México, and Chaco Canyon, New Mexico, and Hovenweep, Utah, United States, reaching thousands of people world-wide. Educational materials and web resources illustrate the seasons and solstice/equinox cycles of the Sun in alignment with ancient cities still observable today (Traditions of the Sun 2005). Many of these sites present unique opportunities to develop authentic cultural connections to Native Americans, highlighting the importance of indigenous knowledge and of the Sun across the ages (Technology through Time 2005). We involved Sun-Earth Connection scientists, their satellite missions, and research programs who shared NASA solar research with diverse audiences (Tracking a Solar Storm 2005).

Through our collaboration, NASA programs benefit from native astronomy resources including the new Navajo Astronomy kits: *Sharing the Skies* developed by IEI and the World Hope Foundation. The kit includes a book of cross-cultural, comparative astronomies (Navajo, Greek and Space Science), flashcards, a poster locating Navajo constellations and a CD featuring Navajo star stories told through music, sound effects and the use of local Navajo actors.

To highlight Native astronomy in our programs, we share the following key messages:

Key messages: Native Astronomy

- Native astronomy emphasizes reciprocal relationship and cyclical processes
- Native astronomy emphasizes culturally relevant, observation-based indigenous science
- Native astronomy incorporates stewardship of Mother Earth and Father Sky
- Indigenous languages carry the meaning of Native astronomy
- Native astronomy emphasizes living the cosmic order

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Our team hopes to continue our collaboration through future opportunities such as the implementation of a distance learning course on Indigenous Astronomy, led by Nancy Maryboy and David Begay in the Physics and Astronomy Department of Northern Arizona University, including western and native participation, along with a Hawaiian teacher education participant cohort, coordinated by Verlieann Malina-Wright and renowned South Pacific cultural astronomer Rubillite Johnson. The mutually beneficial nature of our partnership contributes towards enhanced and more meaningful teaching and learning in the classrooms of Native American students and western students alike. This type of collaboration is innovative for NASA, since it is a collaboration that places native science on par with western science.

Portable *Starlab* Planetarium Demonstrations

Demonstration of our educational resources and of the native and western astronomy knowledge can be accomplished very effectively through *Starlab* planetariums where up to 30 participants can visualize the night and day sky in an inflatable dome with various cylinders that project indigenous and western constellations, along with authentic star fields featuring the movements of objects in the sky. A new Navajo Astronomy cylinder and “Guidebook to Navajo Astronomy” for the *Starlab* developed by the Indigenous Education Institute, and a community-developed CD, *Stars over Dine Bikeyeh*, featuring oral stories and sound effects developed by the Indigenous Education Institute and the World Hope Foundation, enhances our understanding of traditional indigenous astronomy. Within the *Starlab*, it is also possible to highlight new and exciting digitized multi-media approaches including NASA Sun-Earth Connection resources and a newly-released *Traditions of the Sun* website, where audiences can experience first-hand the solar alignments that take place in ancient buildings from Pueblo and Maya cultures, and images of the Sun from space.

With these effective technologies, we can demonstrate rising and setting positions of the stars to highlight the importance of the predawn time to the Navajo and many other indigenous peoples. Navajo ceremonies begin in the evening and are concluded before sunrise. The heliacal rise of stars, namely the first time stars appear in the eastern sky before sunrise, is used for planning ceremony and the cultivation of crops. These phenomena can be well demonstrated in a planetarium dome. The cardinal directions and names in Navajo language – ha’aa’ah: “where the Sun comes up,” etc. can be demonstrated in a visually compelling way inside the portable planetarium, thus reaching tribal and other rural peoples who have little or no access to the planetariums of large cities and universities.

Conclusion

Native science, western science, and native ways of knowing, all have the potential to enrich our understanding of nature and the deep inter-relationships in the Universe. IEI indigenous scholars are continually working to articulate the native ways of knowing the cosmos, and one of their primary audiences is the upcoming generation of

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native peoples. In addition, another important audience includes people from all walks of life who are willing to open their minds to ways of seeing the Universe that go beyond the western paradigm.

The success of our continuing collaboration, in which we juxtapose native and western ways of knowing, rests on the fact that we work together to keep the integrity of each worldview. IEI indigenous scholars participated in NASA-funded projects as members of an Advisory Council and as experts in native astronomy featured in the programming. Their role was critical in ensuring that the project included ways of looking at science concepts that integrated holistic approaches and authentic native knowledge with western research, building the capacity of western scientists and the public to hold divergent views equitably. It is our hope that our collaboration can serve as a fruitful example of a partnership that has provided enhanced access to the wonder, complexity, and beauty of our Universe to diverse audiences.

References, Bibliography, and Related Resources

- AIP 2005 – American Institute of Physics Education and Career Statistics for US Population: (<http://www.aip.org/statistics>)
- Ancient Observatories – Timeless Knowledge Project (<http://sunearth.gsfc.nasa.gov>)
- Begay, David H. and Nancy C. Maryboy, 1998, *Nanit'a Sa'ah Naaghai, Nanit'a Bikeh Hozhoon, Living the Order: Dynamic Cosmic Process of Dine Cosmology*. Ph.D. dissertation. California Institute of Integral Studies, San Francisco, California, University Microfilms, Ann Arbor.
- Cajete, G. 2000, *Native Science: Natural Laws of Interdependence*. Santa Fe, New Mexico: Clear Light Publishers.
- Ludwin, R. S, *et al.* 2005, *Seismol. Res. Lett.*, 76, 431M
- Maryboy, Nancy C. 2004, *A Guide to Navajo Astronomy*, Indigenous Education Institute, Bluff, Utah and Learning Technologies, Somerville, Massachusetts
- Orlove, B. S., Chiang, J. C. H., and Cane, M. A. 2000, *Nature*, 403, 68.
- Stewart, P. J. 2005, *The Chemical Galaxy*: (<http://www.chemicalgalaxy.co.uk>)
- Technology through Time 2005 (<http://sunearthday.nasa.gov>)
- Tracking a Solar Storm 2005 (<http://son.nasa.gov>)
- Traditions of the Sun 2005 (<http://traditionsofthesun.org>)

Biographies

Dr. Nancy Maryboy (Cherokee/Navajo) is Adjunct Professor for the Department of Physics and Astronomy at Northern Arizona University in Flagstaff, Arizona, United States. She has been studying the astronomies of her cultures (Navajo and Cherokee) for many years. Along with Dr. Begay she has developed the *Navajo Star Cylinder*, which is used with the *Guide to Navajo Astronomy* in *Starlab* inflatable planetariums in use throughout the world for school and public audiences. In collaboration with the *World Hope Foundation* of Boulder, Colorado, USA, she and Dr. Begay have written a book called *Sharing the Skies: Stories and Activities of the Navajo and Western Cosmos*. This book features a comparative guide to Navajo, Greek, and western space science and astronomy. They have developed a poster of Navajo constellations and a CD *Stars Over*

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Dine Bikeyah, using traditional Navajo music and storytelling of Navajo astronomy. She is the President of Indigenous Education Institute, a non-profit corporation with the mission of preserving, promoting, and applying traditional indigenous cultures. She works closely with several tribal colleges in the area of indigenous science and in collaboration with Dr. Begay she has developed an internet course on Native Astronomy which is delivered through Northern Arizona University.

Dr. David Begay is Adjunct Professor for the Department of Physics and Astronomy at Northern Arizona University in Flagstaff, Arizona, United States. He has been studying the astronomies of his Navajo culture for many years. Along with Dr. Maryboy he has developed the *Navajo Star Cylinder*, which is used with the *Guide to Navajo Astronomy* in *Starlab* inflatable planetariums in use throughout the world for school and public audiences. In collaboration with the *World Hope Foundation* of Boulder, Colorado, USA, he and Dr. Maryboy have written a book called *Sharing the Skies: Stories and Activities of the Navajo and Western Cosmos*. This book features a comparative guide to Navajo, Greek, and western space science and astronomy. They have developed a poster of Navajo constellations and a CD using traditional Navajo music and storytelling of Navajo astronomy. He is a member of the Dine Medicine Men Association on the Navajo Nation.

Dr. Isabel Hawkins is an astrophysicist at UC Berkeley's Space Sciences Laboratory, Berkeley, California, United States, and a bicultural/bilingual native of Argentina. Her research interests include chemical abundances of the inter-stellar medium, and her dissertation studied the cosmic gas and dust on the line of sight towards the Pleiades among other stars in our Galaxy. Over the past 15 years, she has worked to broaden the participation of underserved communities in space science through education and public outreach. She is interested in exploring the juxtaposition and integration of western and native science strives to practice science within a human context.

Mr. Troy Cline is an Educational Technology Specialist at NASA's Goddard Space Flight Center, Greenbelt, Maryland, United States. He has taught mathematics for several years in the United States including the Navajo Reservation, Africa through the Peace Corp, and several Eastern states. Mr. Troy Cline has done groundbreaking work with multi-media to integrate space science and diverse cultural perspectives, most recently through his leadership of NASA's *Ancient Observatories – Timeless Knowledge* project.