INSPIRE
INTERACTIVE NASA SPACE PHYSICS
IONOSPHERE RADIO EXPERIMENTS

The INSPIRE Journal

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A publication of The INSPIRE Project Inc.

Contents

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INSPIRE'S LEGACY
Dr. William (Bill) W. L. Taylor was a leader in the field of space science education and public outreach. He co-founded and was president of INSPIRE, one of the pioneering successes in NASA Sun Earth Connection Education. NASA Goddard Space Flight Center honored the late William W. L. Taylor with an *Excellence in Outreach in Science* Award for his accomplishments.

MISSION
The INSPIRE Project Inc. is a non-profit scientific, educational corporation whose objective is to bring the excitement of observing natural and manmade radio waves in the audio region to high school students. Underlying this objective is the conviction that science and technology are the underpinnings of our modern society, and that only with an understanding of science and technology can people make correct decisions in their lives, public, professional, and private. Stimulating students to learn and understand science and technology is key to them fulfilling their potential in the best interests of our society. INSPIRE also is an innovative, unique opportunity for students to actively gather data that might be used in a basic research project.

- William W. L. Taylor and William E. Pine, Co-Founders

In 2006, The INSPIRE Project's mission was expanded to develop new partnerships with multiple science projects. Links to magnetospheric physics, astronomy, meteorology, and other physical sciences are continually being explored.

From the Managing Editor

Eva Kloostra

In July 2016 at the conclusion of a workshop for INSPIRE's Space Academy for Educators at NASA Marshall Space Flight Center, solar scientist Mitzi Adams discussed the path of totality of the solar eclipse occurring on August 21, 2017 that would cross the continental United States – an event that had not occurred since 1979. She then invited INSPIRE to partner with scientists from NASA and Austin Peay State University in Clarksville, Tennessee to offer students a hands-on STEM opportunity to conduct various experiments and research. Thanks to our most generous sponsors, friends and volunteers, twelve of INSPIRE's Space Camp for Students alumni who attended the program in elementary and middle school had the once-in-a-lifetime opportunity to be part of the NASA field team for this epic event. The experiments, observations and reports are published in this special edition of *The INSPIRE Journal* including VLF observations using INSPIRE's VLF-3b radio receiver from Dr. Dennis Gallagher of NASA Marshall Space Flight Center. The INSPIRE team sincerely thanks all who made this amazing experience possible!

INSPIRE Solar Eclipse students at Austin Peay State University pictured with volunteer chaperone Juan Flora, Mitzi Adams of NASA/MSFC (center) and INSPIRE Board Secretary Karin Edgett (right)

Interest in VLF radio continues to increase both nationally and globally, and spiked over the summer as a result of the total solar eclipse. INSPIRE's hands-on VLF-3b radio receiver kit continues to be incorporated in middle and high school science curricula, as well as university programs throughout the world for students to experience the sounds of space firsthand. Dr. Andrew Klekociuk, Principal Research Scientist of the Antarctica and the Global System program at the Australian Antarctic Division, purchased INSPIRE's VLF receiver to generate interest from school groups in Tasmania via the Australian Scientists in Schools program. "I was inspired by natural radio as a student and lucky to be taught by G.R.A. Ellis who was a pioneer in whistler research, amongst other areas of radio astronomy," said Dr. Klekociuk. The INSPIRE receiver continues to be incorporated in the arts as well. In Denmark, the Danish Arts Foundation commissioned a permanent installation featuring the VLF receivers *(see page 11).*

INSPIRE Board President Dr. Phillip Webb at the APSU farm in Clarksville, Tennessee

INSPIRE's educational STEM programs for middle/high school educators, students, and college/university students continue to expand. To date, INSPIRE has awarded 137 STEM scholarships and internships thanks to the generous support of program sponsors, partners, friends and volunteers. In INSPIRE's 2016-17 teacher survey, 100% of Space Academy for Educators scholarship recipients reported that they are utilizing materials and knowledge acquired via the program in their classrooms – directly impacting 3,100 students in 32 Washington, DC area schools. Educator recipients continue to serve as ambassadors for INSPIRE promoting STEM disciplines to middle and high school students. In this issue, Van Moreau discusses how participating in INSPIRE's Space Camp for Students propelled his dream of attending West Point to become a pilot and study engineering *(see page 6)*.

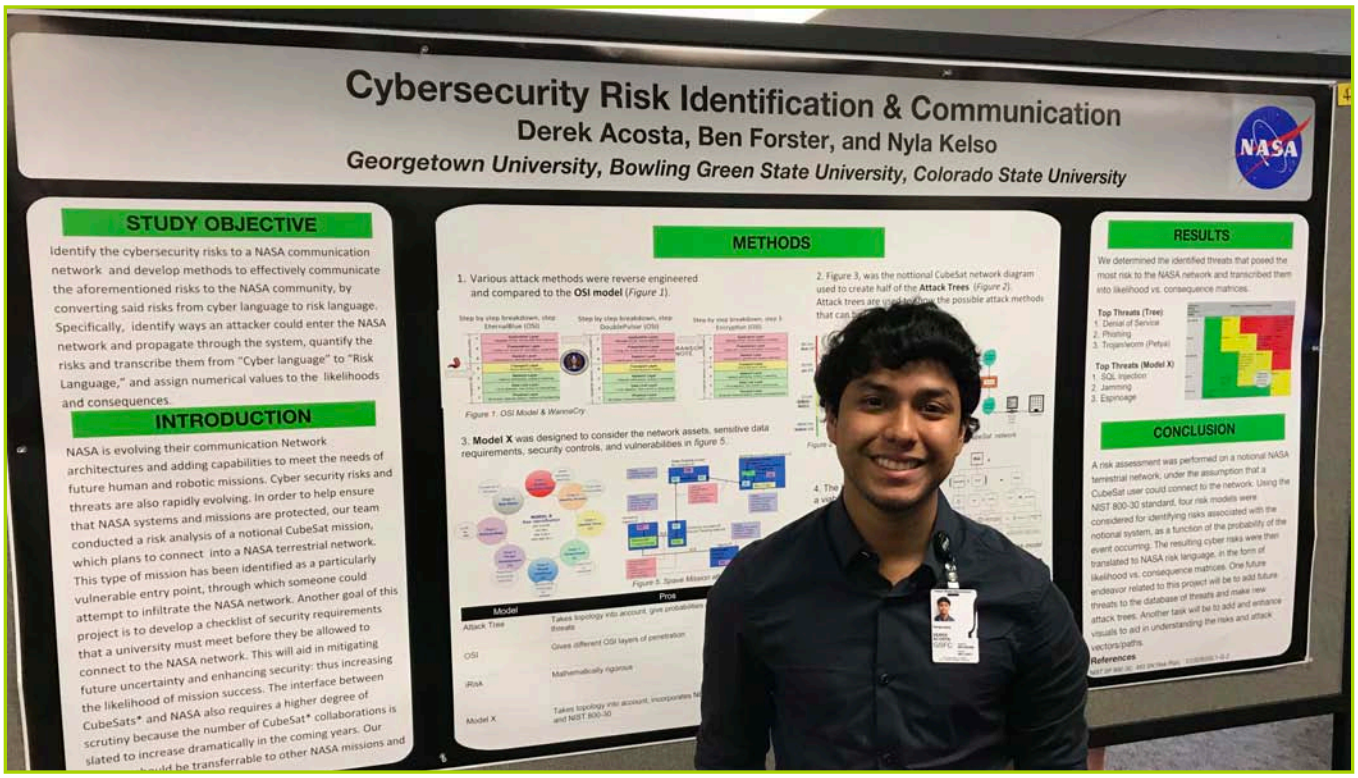
INSPIRE 2010 Space Academy for Educators recipient Alma Smith promoting STEM programs to students at the 2018 NBC Health Fair in Washington, DC

On behalf of the Board of Directors, thank you to our friends, colleagues, volunteers and corporate partners for your continued support of The INSPIRE Project's mission of inspiring our next generation of scientists and explorers.

Special thanks to INSPIRE Advisors Mitzi Adams and Dennis Gallagher of NASA Marshall Space Flight Center for the "solar eclipse experience" and their Journal submissions, Leonard Garcia for technical editing; APSU student photographer Hunter Abrams for providing the cover image (Clarksville, TN), Breeze Design for graphic design services; and to all who contributed to this volume of the Journal.

INSPIRE's NASA Goddard Space Flight Center 2017 Summer Interns Report on Research Projects

INSPIRE partnered with NASA Goddard Space Flight Center and the District of Columbia Space Grant Consortium to offer paid internships at Goddard. This ongoing competition is open to District of Columbia undergraduate and graduate college students. During the past six years, INSPIRE has awarded twenty-four NASA GSFC internships. Each intern is paired with a mentor and works on a STEM research project. For more information, visit TheINSPIREProject.org.



Derek Acosta at the NASA GSFC summer intern poster presentation held in August 2017

Cyber-Security Risk Identification and Communication

Derek Acosta, Georgetown University

I am a computer science major at Georgetown University. This summer I was fortunate enough to be able to participate in an internship at NASA Goddard Space Flight Center under the Mission Software and Ground Systems Assurance Branch. While there, I found the community surrounding NASA GSFC to be gregarious, engaging, and always on the pursuit for understanding and fostering an open and inquisitive environment. Meeting other NASA interns and officials provided me with a new perspective, further enriching my preconceived notions on how NASA plans to "perform flight research and technology integration to revolutionize aviation and pioneer aerospace technology." My project was to assess how cyber risk threats could penetrate a NASA ground system and escalate its way up to a CubeSat Mission Operations Control Center system. Once we would address the course that threat took to infiltrate a computer system or network architecture, we were then tasked with transcribing those threats from cyber language to risk language and addressing likelihood vs. consequence scores in order to map them onto risk matrixes. Even though the project was not necessarily programming oriented, I still found a way to include it by scraping data from the National Institute of Standards and Technology (NIST) National Vulnerability database and Common Weakness Enumeration (CWE) common security weaknesses to glean and hopefully create a statistical model to evaluate and assign threat risks and provide a means of mitigation. Additionally, while here I also worked with two other interns who created their own models which seemed to be more promising though not as mathematically rigorous as the statistical model. Given more time for analysis of the data retrieved and authorization to view the controls used on NASA's network architecture, my model would have been able to deliver more. Although this project was not specifically oriented towards the integration of technology, much value was still derived from it, as it would serve as a means to communicate cyber risk language to risk language in a manner that the NASA community could relate.

My experience at NASA GSFC has shaped my career plans by giving me more perspective and options to consider within the field of computer science. I am tremendously grateful for this opportunity to explore the possibilities at NASA and I am thankful to The INSPIRE Project for making this possible for me.

Guidance, Navigation, and Control (GN&C) Hardware and Components Analysis 2

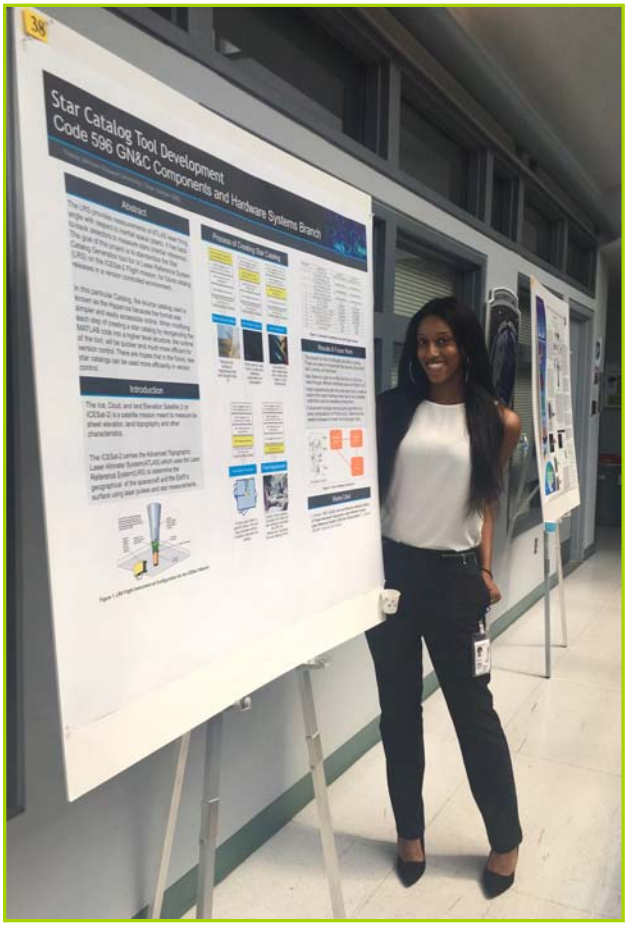
Tramia Johnson, Howard University

I am studying Computer Engineering at the illustrious Howard University. Thanks to The INSPIRE Project, I had an amazing opportunity to intern at NASA Goddard Space Flight Center during the summer of 2017.

Working with Sean Semper in the Guidance, Navigation & Components office to benefit his flight development efforts was an experience to remember. I helped him work to standardize the Star Catalog Generation tool for the Laser Reference System (LRS) on the ICESat-2 Flight mission for future catalog releases. We were formatting the original code to a lower level coding language to be read easily in a version controlled environment.

During my ten weeks, I learned three coding languages and became proficient in all three. I got to explore the facilities and venture outside my field to explore other career opportunities. What NASA GSFC taught me is that you might not always stick to the field you have a degree in.

It has always been a dream of mine to work for NASA and become an innovator for the new world. Being able to talk to scientists and engineers that made their dreams into their reality only inspired me to work harder and be the best I aspire to be. Thank you, INSPIRE.



Tramia Johnson presenting her research project - Star Catalog Tool Development - at the NASA GSFC 2017 poster presentation

INSPIRE Annual NASA GSFC Intern Lunch – August 2, 2017

The INSPIRE Project hosts an annual lunch for their NASA Goddard Space Flight Center summer interns to meet, network, and discuss their research projects and experiences at NASA.

(RIGHT - pictured left to right) Tramia Johnson (intern), Dr. Leonard Garcia of NASA GSFC who volunteers as a Space Physics Advisor for INSPIRE, Derek Acosta (intern), and INSPIRE Board President Dr. Phillip Webb

The INSPIRE Project would like to thank NASA Goddard Space Flight Center and the District of Columbia Space Grant Consortium for their continued support of this program; the NASA GSFC Education Office for the facilitation of the internship awards; and the dedicated mentors for their inspiration and guidance.

A special thanks to Dr. Leonard Garcia for his assistance with INSPIRE's NASA GSFC Internship Program each summer.

Visit TheINSPIREProject.org for Complete Program Information

INSPIRE Educational STEM Programs

College / University Scholarships

Dr. William W.L. "Bill" Taylor Memorial STEM Scholarship

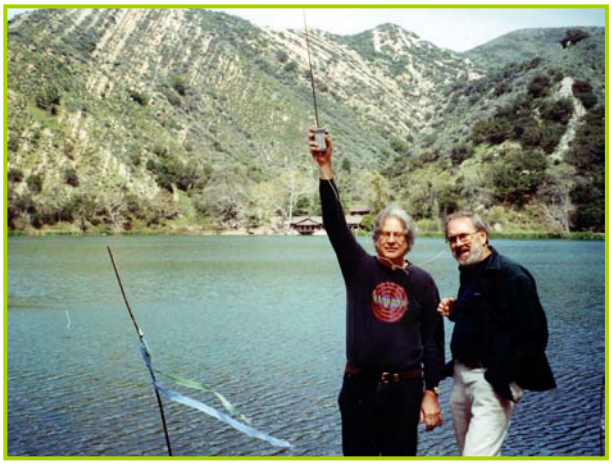
Scholarship Awards: Up to $4,000 per recipient
Application Deadline: Ongoing

In honor of INSPIRE's co-founder Dr. Bill Taylor, The INSPIRE Project with its partners at the District of Columbia Space Grant Consortium and other science and technology organizations established this STEM (Science, Technology, Engineering, Mathematics) scholarship to help ensure our next generation of scientists and explorers. Undergraduate/graduate and high school seniors who are majoring in a STEM discipline and are currently or will be attending a Washington DC college or university are encouraged to apply. *Apply Online at TheINSPIREProject.org – College/University Scholarships*

Eligibility Requirements

All applicants must meet the following requirements and submit the required documents as outlined below:

- U.S. citizenship
- Demonstrate above-average performance in academic work through his/her GPA
- Be registered as a full-time student in good standing at a Washington DC college or university
- Must be majoring in a STEM (Science, Technology, Engineering, Mathematics) discipline
- Submit current transcript
- Submit two letters of recommendation with at least one from a teacher or faculty member
- Submit a 300 to 500 word essay discussing how this scholarship award will help you advance in STEM disciplines and the positive impact it will have on your future career plans



INSPIRE's co-founders Dr. Bill Taylor (right) and Bill Pine (left)

College / University Internships

NASA Goddard Space Flight Center Summer Internship Program

Internship Awards: $6,000 Undergraduate / $7,500 Graduate Students
Internship Session: Early June - Early August (10 weeks, full-time)
Application Period: November - February *(see NASA website for dates)*

With support from the District of Columbia Space Grant Consortium and other partners, The INSPIRE Project offers paid full-time summer internships at NASA Goddard Space Flight Center.

Internship Description

NASA summer internships are educational hands-on opportunities that provide unique NASA-related research and operational experiences for undergraduate and graduate students. The internships integrate participants with career professionals emphasizing mentor-directed, degree-related, real-time world task completion.

NASA Goddard Space Flight Center aerial photo courtesy of NASA

NASA Goddard Space Flight Center Summer Internship Program *continued*

During the 10-week summer internship, participants engage in scientific or engineering research, development, and operations activities. Through these internships, participants leverage NASA's unique mission activities and mentorship to enhance and increase their professional capabilities and clarify their long-term career goals. Upon completion of internships, recipients are required to submit an article on his or her research project for inclusion in The INSPIRE Journal.

Eligibility Requirements

Below are the NASA Goddard Space Flight Center internship requirements:

- U.S. citizenship
- Minimum 3.0 GPA on a 4.0 grading scale
- Applicants must be enrolled full-time in a degree-granting course of study appropriate to NASA's long-term professional workforce needs
- INSPIRE summer internship applicants must be undergraduate or graduate students enrolled at a Washington DC college or university

Applicants must complete the required NASA internship application which includes a letter of recommendation and current college/university transcript

For more information and to apply, visit the NASA internship website:
Intern.NASA.gov

Middle & High School STEM Educators

Kathleen Franzen Memorial Space Academy for Educators Scholarship Program

Weeklong Summer STEM Program at the U.S. Space & Rocket Center in Huntsville, Alabama
(Check INSPIRE website for program dates)

The INSPIRE Project has teamed up with the U.S. Space & Rocket Center, District of Columbia Space Grant Consortium, Washington Space Business Roundtable and other partners to offer Washington DC middle and high school teachers /administrators full scholarships to attend Space Academy for Educators in Huntsville, Alabama.

The weeklong program during the summer includes authentic astronaut training simulators and activities developed to promote learning in a classroom setting. Curriculum includes NASA content and is correlated to the Next Generation Science Standards (NGSS).

Trainees in Space Academy for Educators can earn 45 professional development hours and educators get access to a shared website with lesson plans, networking opportunities, and tips to adapt many of the workshop activities to individual class environments.

Workshop topics/activities include:

- Engineering Design Challenges
- Rocket Construction
- Math Workshops
- Living and Working in Space
- Orion Spacecraft
- Space History
- Mars & the Moon

Teachers participate in two simulated space shuttle missions, simulate walking on the moon and working in the frictionless environment of space on astronaut simulators and weather permitting, spend an afternoon at Aviation Challenge simulating parachute landings and helicopter rescues in the water.

Space Academy for Educators full scholarships include:

- Round-trip airfare from the Washington DC metro area to Huntsville, AL
- Six nights lodging and meals
- Program materials, flight suit, T-shirt and USSRC exhibit ticket
- Transportation to/from the airport in Huntsville

Apply Online at TheINSPIREProject.org – Space Academy for Educators Scholarships

INSPIRE's late president Kathleen Franzen founded the Space Academy for Educators and Students programs. She is pictured with her husband, INSPIRE's co-founder Dr. William Taylor

Middle & High School Students

Kathleen Franzen Memorial Space Academy for Students Scholarship Program

INSPIRE's Weeklong Summer STEM Program for Washington DC Area Middle School & High School Students at the U.S. Space & Rocket Center in Huntsville, Alabama
(Check INSPIRE website for program dates)

The INSPIRE Project has teamed up with the U.S. Space & Rocket Center, Washington Space Business Roundtable and other sponsors to offer full scholarships to Space Academy in Huntsville, Alabama for Washington DC area high school and middle school students.

Space Academy is an action packed 6-day program for students world-wide to participate in classroom, laboratory and training focused on space science and space exploration. Space Academy encourages teamwork, problem solving, communication skills and self-confidence. Students take part in astronaut-style training and simulations, as well as STEM activities to ensure our next generations of space science and technology explorers!

- Tumble and spin in the Multi-Axis Trainer
- Float on air in the 5-Degrees of Freedom Chair
- Walk like Apollo astronauts in the 1/6 Gravity Chair
- Experience a world without friction in the MMU
- Challenge yourself and support your Team at Area 51
- Pilots/Commanders land the Space Shuttle
- Mission Specialists walk "in space" on an EVA (Extra Vehicular Activity) to repair the Hubble Space Telescope
- Live and work in space operating the ISS life support
- Perform scientific experiments on soil samples from Mars

Space Academy for Students full scholarships include:

- Round-trip airfare from Washington DC to Huntsville, Alabama *(INSPIRE chaperone accompanies students)*
- 5 Nights lodging & meals at the U.S. Space & Rocket Center
- Program materials, flight suit, team patch, T-shirt & DVD
- Transportation to/from the airport in Huntsville

Apply Online at TheINSPIREProject.org – Space Academy for Students Scholarships

Special Thanks to The INSPIRE Project's Program Sponsors, Supporters and Volunteers!

NASA | District of Columbia Space Grant Consortium | Washington Space Business Roundtable
U.S. Space & Rocket Center | International Launch Services | Space Ad Agency

The INSPIRE Project's Dr. William W.L. "Bill" Taylor Memorial STEM Scholarship Recipient

Kuishon A. Brown

In honor of INSPIRE's co-founder Dr. Bill Taylor, The INSPIRE Project with its partners at the District of Columbia Space Grant Consortium and other science and technology organizations established this university STEM scholarship to help ensure our next generation of scientists and explorers. To date, fourteen scholarships have been awarded. Undergraduate, graduate and high school seniors who are majoring in a STEM discipline and are currently or will be attending a Washington DC college or university are encouraged to apply online at: TheINSPIREProject.org (College/University Scholarships)

Howard University Chapter of Sigma Phi Delta

As a recipient of The INSPIRE Project's Dr. William W.L. "Bill" Taylor Memorial STEM Scholarship, I am excited to share the many successes and opportunities this aid has provided for me.

It is not an exaggeration to say that my tenure at Howard University this past school year (2016-2017) has given me zero financial burdens regarding academics. The funds provided not only relief, but an ever-growing determination to pay it forward – in full – to future young students matriculating through the field of STEM (Science, Technology, Engineering, and Mathematics).

With the monetary funds, time normally put towards working part-time on a daily basis, was put towards developing my academic and professional livelihood. On one hand, taking up more coursework necessary for the completion of my degree was a very successful endeavor. On another, I was successful in securing an internship at Boeing to continue the climb towards professional success.

Whether it is regarding on or off-campus activities, I have had a serious load lifted from my shoulders. As I look towards the completion of the 2017-2018 school year, I am filled with vigor and plans to contribute to the university. So far, much time has been attributed into chartering the first DC and HBCU chapter of Sigma Phi Delta – an all-male engineering fraternity. Now complimenting the close of an academically successful fall 2017 semester, the fraternity has finally achieved approval and recognition by Howard University. Now, with a developing foundation, I along with my cohorts can implement programs and initiatives planned for the growth of the engineering profession at Howard University and beyond within the metropolitan area.

Thus far, I have personally reached out to off-campus organization such as: CIA, Boeing, Apple, Apex-Clean Energy, and The INSPIRE Project with hopes of a future on-campus collaboration. All this is in order to pay it forward to young engineers who will soon grace the doors of the College of Engineering and Architecture. Though there were many obstacles in place, INSPIRE has driven me to not frown in the face of a wall - simply, to rise above it.

About Kuishon Brown

Kuishon Brown is currently a senior at Howard University in Washington, DC majoring in Mechanical Engineering. Kuishon was born in Massachusetts and moved to Brooklyn, New York where his parents reside. He enjoys stepping, playing the cello, reading, basketball, public speaking and networking.

Kuishon's accomplishments to date include: 2014 BAI scholarship recipient, School Technology Summit 2015 - Welcoming Speaker, NSBE NLI Participant/Mentee 2015-2016, JP Morgan Launching Leaders Program 2016, The IMPACT Movement FRC 2015 & 2016, and a member of the HU Boeing Team 2015-2016.

His future career goals are to work in the field of Aerospace Engineering and research renewable energy at a reputable company. He hopes to open his own practice within the field of renewable energy - based in a "green country" (i.e. Iceland). Kuishon is a firm believer of "treating the whole by each part" and strives to work with other outstanding peers. He stands by the mantra "to become a better person today, than the man I was yesterday" and strives daily to follow and build upon this objective.

56°25’59” N 8°46’35” Ø 52 M OVER HAVET

INSPIRE VLF Kits featured in Danish Arts Foundation Permanent Installation

Christian Skjødt

56°25’59” N 8°46’35” Ø 52 M OVER HAVET (*56°25’59” N 8°46’35” E 52 M OVER SEA LEVEL*) is a permanent installation created for Margrethe Reedtz Skolen in Ryde, Denmark in a collaboration between sculptor Jørgen Carlo Larsen and sound artist Christian Skjødt.

Emerging as a sort of foreign object in the small village of Ryde in the northern part of West Jutland, the site-specific art work unfolds as a cube of glass and steel that houses mirrors, loudspeakers and antennas mounted on a laboratory stand-like sculpture.

Here sounds of the earth's natural radio signals, found in the ionosphere 90 km above ground surface, are picked up by four INSPIRE VLF-3 radio receivers via custom built copper loop antennas. A computer with special designed software controls this live natural radio observatory and creates an ever-changing soundscape conveyed by eight loudspeakers inside of the cube that mingles with visual reflections caused by the sculpture's many extroverted mirrors.

Through a corps of key guardian ambassadors in the local community, it is possible to enter the cube, and let your mind drift out into the upper atmosphere of the planet and the immediate mirroring of the face of Ryde, as the work invites us into a space of thoughtfulness - scientific as well as epistemological.

56°25’59” N 8°46’35” Ø 52 M OVER HAVET was inaugurated June 24, 2016 and donated by the Danish Arts Foundation.

About Christian Skjødt

Christian Skjødt is a Danish artist who explores the material and aesthetic interrelations between sound, body and memory. His installation works deal with the imperceptible. Often working site-specific Skjødt sets up autonomous systems out of which immersive environments emerge. He compiles installations with a laboratory approach in which technical and physical experiments play a central role. Working with sound as primary materiality Skjødts work in many ways bypasses the intellect and ‘speaks’ directly to the body, reminding us of the direct link between the body, thinking and reality. With a serial approach his works usually consist of multiples that investigate principles that ‘investigate themselves’ and furthermore the space they are in. His work is based on the physicist’s approach of allowing objects and materials to be what they are. But at the same time Skjødt creates spaces that force us to relate to the current place and time. His works can be seen as witnesses to what we are unable to perceive and the boundary between our sensory apparatus and the materiality of the world. Besides his solo career he has taken part in numerous collaborations, working interdisciplinary in the fields of composition, installation, theatre, dance and performance. He is also the founder and curator of the vinyl imprint Tonometer, objectifying exploratory sounds and music. Christian Skjødt currently lives and works in Copenhagen, Denmark, and holds a Master's degree from the Royal Academy of Music in Denmark. To learn more visit: Skjodt.net

Installation photography courtesy of Erling Lykke Jeppesen

August 21, 2017:
A Solar Eclipse for the United States

M.L. Adams[1]
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ABSTRACT
For the first time in almost 100 years, the narrow path of the Moon's shadow fell upon the United States, stretching from one coast to the other; everyone in the U.S. could see at least a partial solar eclipse. For those in the path of totality, in addition to photographing an awe-inspiring sight, there were opportunities to perform scientific research under relatively unique conditions. This article will describe the partnerships and projects that were developed for the total solar eclipse of August 21, 2017.

Keywords: Solar eclipses

1. INTRODUCTION
A total solar eclipse is such an unusual and somewhat frightening phenomenon that our ancestors revered their astronomer priests. In the case of the Inca civilization however, those priests took their power from being able to keep a calendar; but surprisingly, they could not predict eclipses, which exalted the Spanish conquerors because they could (Bauer & Dearborn 1995). To predict eclipses today, we use the power of the computer and an understanding of orbital mechanics. In addition, when combined with observations from the Lunar Reconnaissance Orbiter (see https://lunar.gsfc.nasa.gov), which provides details of the lunar-limb profile, the result is the most precise and accurate prediction of an eclipse's path of totality (*e.g.*, see https://eclipse2017.nasa.gov/eclipse-maps). Knowing this path accurately allowed millions of people in the United States to plan travels to view this phenomenon first hand, and hopefully has inspired another generation to study Science, Technology, Engineering, Arts, and Mathematics (STEAM).

Since the birth of the United States in 1776, there have been twenty total-solar eclipses, whose paths of totality have touched some part of the continental United States: June 24, 1778; October 27, 1780; June 16, 1806; November 30, 1834; July 18, 1860; August 7, 1869: July 29, 1878; January 1, 1889; May 28, 1900 (0.99% total in Atlanta, Georgia); June 8, 1918 (bisected the U.S. like 2017); September 10, 1923 (through a tiny bit of SW California); January 24, 1925 (New York, New Jersey, Pennsylvania); August 31, 1932 (Vermont, New Hampshire); July 9, 1945 (only Idaho and Montana); June 30, 1954 (Nebraska, Minnesota, Michigan); October 2, 1959 (New Hampshire, Massachusetts); July 20, 1963 (Maine); March 7, 1970; February 26, 1979, and August 21, 2017 (see the World Atlas of Solar Eclipse Paths, Second and Third Millennia CE https://eclipse.gsfc.nasa.gov/SEatlas/SEatlas.html#2CE).Thomas Jefferson attempted to observe the first solar eclipse to be recorded in the new United States in 1778, but there were clouds at his observing site in Virginia (see https://www.monticello.org/site/visit/events/jefferson-and-solar-eclipses). The first American eclipse expedition was mounted for the 1780 eclipse, led by Professor Samuel Williams from Cambridge; the observers were located at Penobscot Bay in Maine, where inaccurate calculations of the path of totality placed them just outside it. Professor Williams did however observe Baily's Beads, and wrote:

> After viewing the Sun's limb about a minute, I found almost the whole of it thus broken or separated in drops, a small part only in the middle remaining connected (Todd 1894).

Vassar College's first professor, Maria Mitchell, led her students to view the total solar eclipses of 1869 and 1878. Observations made by the women of the 1869 eclipse were published in the *American Ephemeris and Nautical Almanac* (see http://vcencyclopedia.vassar.edu/faculty/original-faculty/maria-mitchell1.html). The eclipse expedition to view the July 29, 1878 total solar eclipse included Professor Mitchell, her sister, and four Vassar graduates. Although these women endured lost luggage, which threatened to prevent them from observing the eclipse (near Denver, Colorado), they were still able to set up camp with their telescopic equipment in time. This expedition was privately funded by Professor Mitchell, since no outside funding source would do so, because all participants were female.

Quite a different situation existed for the August 21, 2017 solar eclipse. Many women and young girls, men and young men, were involved in this event, and were funded to organize, observe, carry out experiments, and report on this eclipse. Plans began in 2015 between Dr. Allyn Smith of Austin Peay State University (APSU) and myself, with a few simple words by Dr. Smith, "The path of totality goes through the APSU campus. We should plan something together." From that humble beginning, and in addition to the participation of The INSPIRE Project, we were able to involve the U.S. Space and Rocket Center (USSRC) in Huntsville, Alabama, Marshall Space Flight Center's (MSFC) TV crew, school systems in Clarksville, Tennessee and Hopkinsville, Kentucky, and the Space Hardware Club of the University of Alabama in Huntsville (UAH).

2. EXPERIMENTS

Austin Peay State University offered the perfect location for science experiments during the eclipse. APSU's Agriculture Department, headed by Dr. Donald Sudbrink, operates a working farm and Environmental Center, just ten minutes from the main campus. The Physics and Astronomy Department has established an observatory there, complete with concrete pads and power for telescopes. There are also two air-conditioned classrooms, a necessity for us in the middle of August in the southeast United States.

Figure 1. *Totality from Hopkinsville, Kentucky: This image, taken by Joe Matus of NASA/MSFC, shows the state of the corona on this date, August 21, 2017.*

We used the larger of the two classrooms for meals and for discussions of student projects, which included:

- observations of the behavior of animals to include cows, crickets, turtles,
- balloon launches with payloads that included geiger counters, real-time streaming video, temperature and pressure measurements,
- investigation of conditions of the ionosphere using Ham radio,
- investigation of conditions of the ionosphere using Very Low Frequency radio (using an INSPIRE receiver),
- observations of the eclipse phenomenon known as shadow bands,
- tracking air temperature changes for NASA's Global Learning and Observations to Benefit the Environment (GLOBE) project,
- general eclipse photography,
- language arts practice and journaling the eclipse experience.

2.1 Animal Behavior

One study in the agricultural literature, reported that the total solar eclipse of August 11, 1999 had no affect on the grazing behavior of lactating cows (Rutter 2002), even though light intensity is hypothesized to be an important factor. That study prompted Dr. Rod Mills to lead an investigation of the behavior of APSU cows during the eclipse. To prepare for the observations, INSPIRE students, used a non-toxic spray paint to paint numbers on the cows (see Figure 2). Before the eclipse

began, the cows were led to pasture, where the students could see them easily. The plan was to observe ten cows, but only eight cooperated. All eight placed themselves in the shade of a tree before the eclipse began, and only one of them moved from the shade during totality.

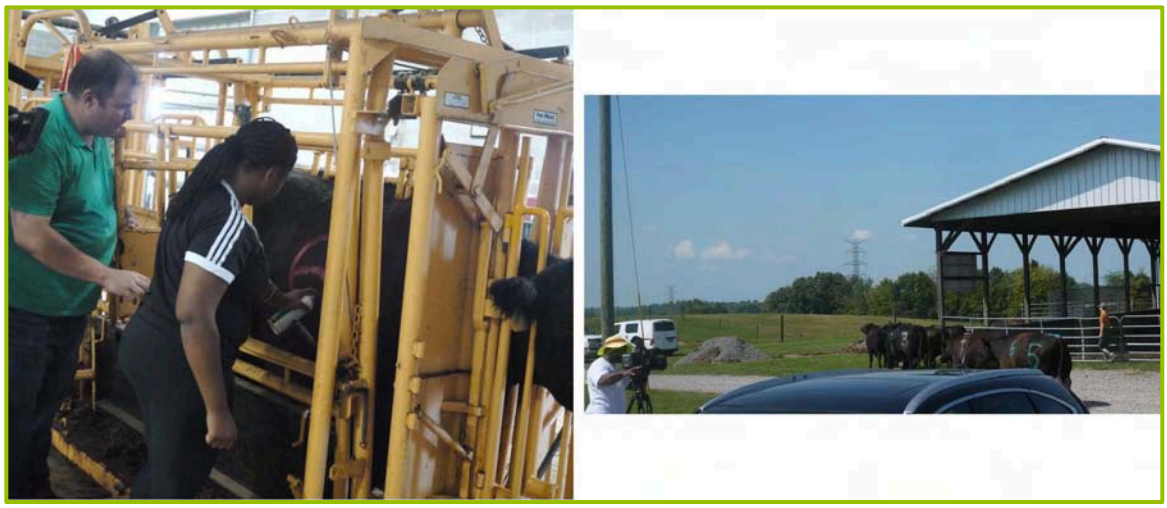

Figure 2. *On the left, an INSPIRE Project student spray paints a cow with a number for easy tracking. On the right, all numbered cows are moving toward their pasture on eclipse day. Photos courtesy of The INSPIRE Project.*

Dr. Sudbrink, an entomologist by trade, proposed using crickets to investigate behavior changes during the eclipse. Students from the USSRC's Space Camp assisted in the observations of ten crickets, one cricket per cage, all kept in the shade during the eclipse, with food and water (see Figure 3). Serendipitously, one of the students noticed that turtles were leaving a nearby pond as the eclipse proceeded. By the time totality occurred, there were 40 turtles on the bank of the pond. Two hours later, as light and heat intensity increased, there were only seven.

Figure 3. *Ten crickets (Acheta domesticus) are housed in the colorful cages, one per cage. The image on the right shows one of the turtles (Trachemys scripta, or pond slider) that exited the pond during the eclipse. (Images courtesy Dr. Donald Sudbrink)*

2.2 Balloon Experiments

The Montana State Balloon Project, in partnership with NASA's Space Grant Consortium and NOAA, organized fifty teams from across the country to fly high-altitude balloons during the total solar eclipse. Each team flew a primary payload consisting of downward-looking video cameras, which streamed to the NASA website (https://eclipse.stream.live/). Teams could choose to fly a secondary payload of their choice. The University of Alabama in Huntsville (UAH) team, for example, flew hops for a local brewery, which then produced an "eclipse beer". In addition, the Jet Propulsion Laboratory provided samples of bacteria to investigate the effects of radiation and reduced atmospheric pressure at 100,000 feet, conditions similar to Mars. Three teams participated at APSU: APSU itself, Arkansas State, and UAH (see Figure 4).

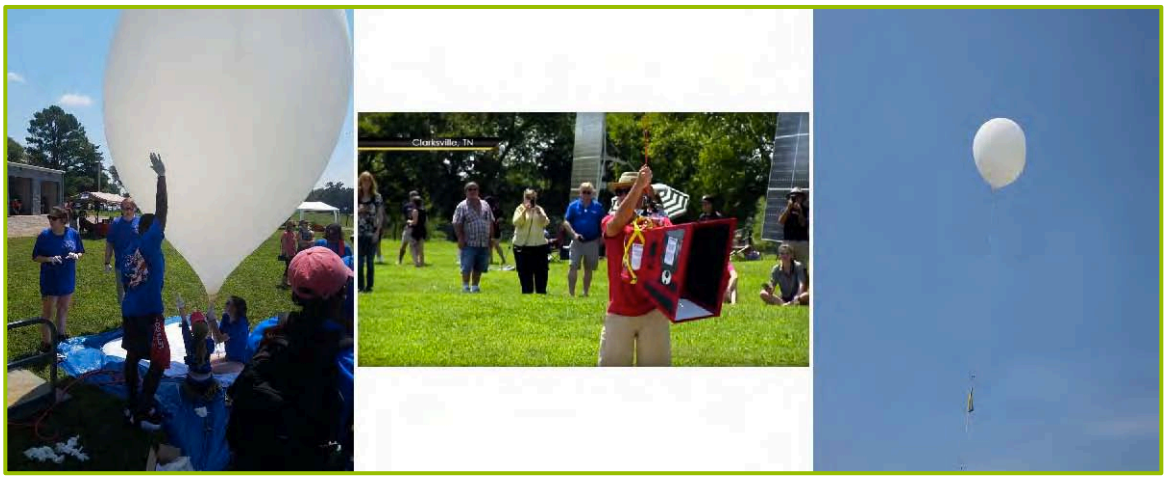

Figure 4. *Left: INSPIRE Project students hold and fill a balloon. Middle: APSU Physics Department Laboratory Manager Bryan Gaither holds the APSU balloon, prior to launch. Right: Launch! (Left and right images courtesy of The INSPIRE Project, middle image from NASA's video of the eclipse)*

2.3 The Ionosphere

It is well known that X-and UV-radiation from the Sun ionizes atoms and molecules in our atmosphere during the day and that at night electrons recombine with their parents. The net effect is that radio waves can travel farther at night. During the day, a radio signal (if not of very high frequency) will either be weakened or will "bounce" off the ionized "D" layer of the ionosphere, as seen on the left side of the right panel in Figure 5. When the D layer "opens up at night', the transmitted signal goes higher before it is reflected back to Earth, thus it travels farther. Because conditions during an eclipse mimic (for a short time, anyway) night-time conditions, experiments were conducted during the eclipse, with the hope of better understanding the physical properties of the ionosphere. Based on knowing the locations of high-frequency radio transmitters and distance to receivers, temperature and density of the layer through which the radio wave travels could be determined. Many ham radio operators participated in this type of experiment through the Reverse Beacon Network. Dr. Ghee Fry of NASA/MSFC joined with citizen scientist Linda Rawlins at the APSU farm to set up a radio receiver to participate in this experiment. INSPIRE students and USSRC Space Campers were also involved. The one-line essential result from the experiment is that the behavior of the ionosphere during the eclipse was consistent with a day/night transition.

In another part of the electromagnetic spectrum, Dr. Dennis Gallagher set up an INSPIRE Project receiver to listen for Very Low Frequency radio signals. The time around dusk, either morning or evening, is the optimal time to listen, since "holes" open up in the ionosphere, and waves produced by lightning, can be ducted by Earth's magnetic field to locations very far away from the storm that produced the lightning. If conditions are just right, the wave will bounce back and be stretched out, or dispersed. Higher frequencies arrive first back at their starting position, lower frequencies arrive later, creating a "whistle", thus the phenomenon is called "whistlers". Other sounds can also be heard, spherics and tweeks. Spherics can be heard all the time, tweeks, which are slightly dispersed, more infrequently. Figure 6 (right) shows the INSPIRE receiver, connected to a digital recorder, which also had input from a radio for time stamp. Dr. Gallagher heard a lot of spherics, and a tweek or two, but no whistlers. He discusses more details of this experiment in this Journal (see page 19).

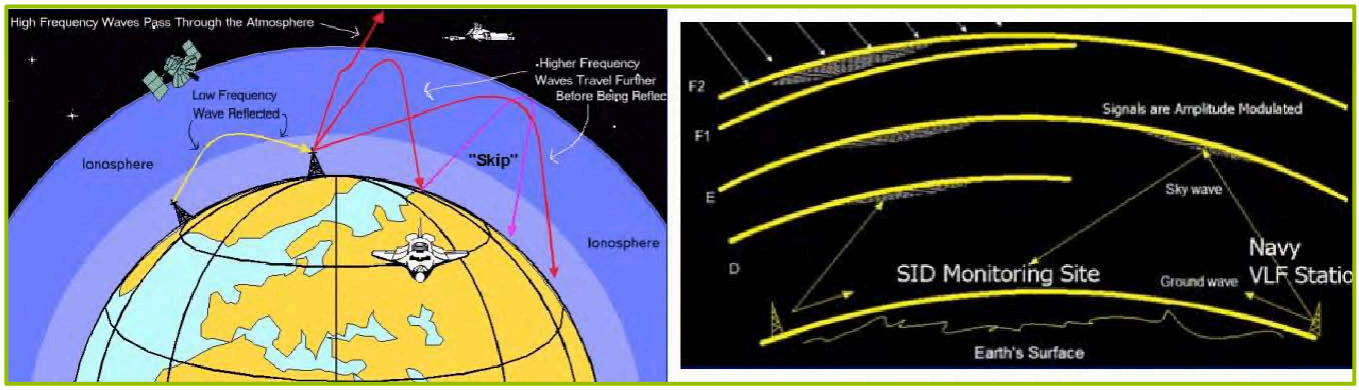

Figure 5. *The image on the left shows how radio waves propagate in the ionosphere (from https://swpc.noaa.gov/phenomena/ionosphere). Low frequencies reflect at a lower altitude and do not travel long distances, higher frequencies travel higher before reflecting. The highest frequencies do not reflect at all. The image on the right shows how upward-propagating-radio waves travel farther with no D region.*

Figure 6. *Left: Dr. Dennis Gallagher relaxes under the canopy after confirming that the INSPIRE receiver (Right) was working properly. Both images are courtesy of Ms. Karin Edgett of The INSPIRE Project.*

2.4 Shadow Bands

A very difficult phenomenon to record, either by video or still imaging, shadow bands have been hypothesized to be the result of a "slit" of sunlight shining through turbulent layers of Earth's atmosphere. The perceived effect is similar to the wavy patterns seen in a pool when sunlight shines through the water. Observers have reported a snake-like appearance of alternating dark and light bands that move in a particular direction, often in the direction of motion of the umbral shadow. We hoped to gather more data about this phenomenon, for example, size of the bands and direction of motion. We therefore directed the USSRC Space Camp students to build shadow-band-boxes, inside of which the students' cell phone could be placed. With a translucent top on the box, the eclipse shadow bands should appear. Some shadow bands were seen with this set up, but because contrast was so low, no measurements could be made. However, a Space Camp student, Michaela Mason, at the VLF site with Dr. Gallagher, positioned her cell-phone camera above a sheet (see Figure 7). Cardinal directions and the direction of the approaching shadow were noted on a card placed on the sheet. Ms. Mason's video is being analyzed and may have enough contrast for quantitative measurements to be made.

Figure 7. *These images show our attempt to make a video record of shadow bands. Top Left: A smart phone is centered in a "shadow-band box", camera side facing upward. Top right: On top of the box is translucent material, like tracing paper or waxed paper, onto which fiducial marks can be made, similar to the ones on the bottom right image. Bottom Left: At the APSU farm, the USSRC students placed their shadow-band boxes in the field close to the wind turbine. Bottom Right: INSPIRE Project students and USSRC student, Michaela Mason, position a sheet with fiducials and meter sticks for scale, in preparation for shadow bands. Image Source: Dr. Gordon Telepun, top images; Mitzi Adams, NASA/MSFC, bottom left; Michaela Mason, bottom right.*

2.5 Temperature Changes

When the Sun sets, the temperature goes down. Similarly, when the Sun is blocked by the Moon during a total solar eclipse, the temperature decreases; but by how much? This was the question asked by NASA's Global Learning and Observations to Benefit the Environment (GLOBE) Observer Program (see https://observer.globe.gov/science-connections/eclipse2017). Citizen scientists across the nation collected more than 80,000 air temperature measurements! The maximum temperature drop at any particular site depends on a lot of factors that include terrain, elevation, and local weather patterns. Figure 8 shows data from two different eclipses. On the left is a plot of the temperature decrease during the June 21, 2001 total solar eclipse, which occurred over Lusaka, Zambia. The observation site was at a hotel; the temperature sensor was set approximately 0.3 m off ground composed of white gravel and concrete. The temperature change from before the eclipse began to the minimum temperature, was approximately 13◦ F (7◦ C change). For the August 21, 2017 eclipse in Clarksville, Tennessee in an area with a lot of pasture and very little concrete, the minimum temperature was 27.8◦ C (82◦ F), giving a 9.2◦ C (16.6◦ F) difference from the maximum prior to the eclipse. The minimum on the plot, is the "v" on the right side at about 1:30. The Clarksville Farm's latitude and longitude are noted on the upper right of the plot, 36.56◦ North and 87.34◦ West. For comparison, Lusaka is 15.39◦ South and 28.32◦ East. Minimum temperatures taken during total solar eclipses typically lag totality by a few minutes, because the atmosphere needs time to respond to the drop in solar radiation.

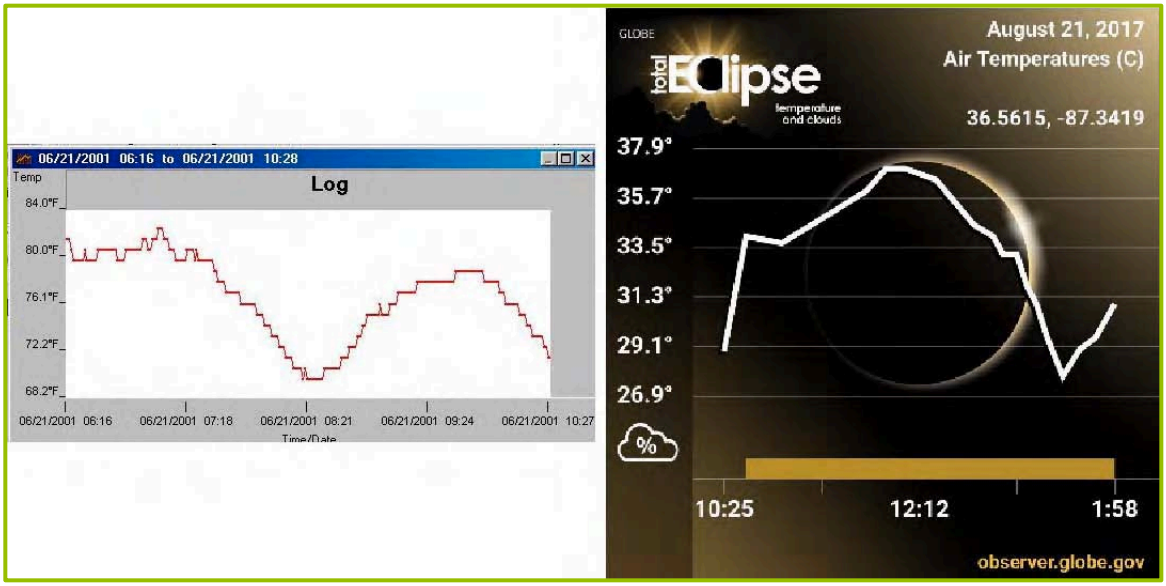

Figure 8. *Left: A plot of the temperature decrease in Lusaka, Zambia during the total solar eclipse of June 2001, data taken by Mitzi Adams, NASA/MSFC. Right: The GLOBE project supplied a kit with which to make temperature measurements, data taken by Dr. Pete Robertson, NASA/MSFC, and USSRC and INSPIRE Project students.*

2.6 Eclipse Photography

The images in this section show several ways that the Sun can be photographed during a total solar eclipse. Figure 9 top left shows the beginning of the partial phase of the eclipse or, "first contact", when the Moon begins to cover the Sun. This particular image was taken at the APSU Farm in Clarksville with a hydrogen-alpha telescope. Hydrogen-alpha, or H-α, is a specific wavelength of light at 656.28 nm emitted when a hydrogen atom's electron relaxes from its third lowest to its second lowest energy state. On the Sun, this light is created in the chromosphere, the middle layer of the Sun's atmosphere (the photosphere is the lowest, the corona the highest). The reddish color of H-α was first observed during a total solar eclipse, when the chromosphere sticks up above the limb (edge) of the Moon. The H-α telescope allows us to observe the full-disk chromosphere, where we often see flares, filaments (same as prominences when viewed on the limb), and active regions, or groups of sunspots.

On August 21, there were two active regions, one to the right of the center of the solar disk, the other close to the left limb (edge). The top right panel of Figure 9 shows the corona of the Sun and the "Diamond Ring" effect close to totality. An eclipse photographer has two opportunities for the Diamond Ring, before and after totality, as the last bit of sunlight is obscured or uncovered by the Moon. The image on the bottom left essentially shows what the unaided eye sees, a black hole in the sky, surrounded by the pearly-white light of the corona. An entire sequence of images is on the bottom right, showing the progression of the eclipse from first contact (left Sun) through the partial phases to totality, to the Diamond Ring after totality, through partial phases to fourth contact (right Sun), when the eclipse is over. The arc formed by this sequence of images shows how the Sun rises to its highest elevation at midday, and moves lower in the sky as it sets toward the west. Totality occurred at approximately 1:30 p.m. Central Daylight Time, about one-half hour after astronomical midday, when the Sun is due South.

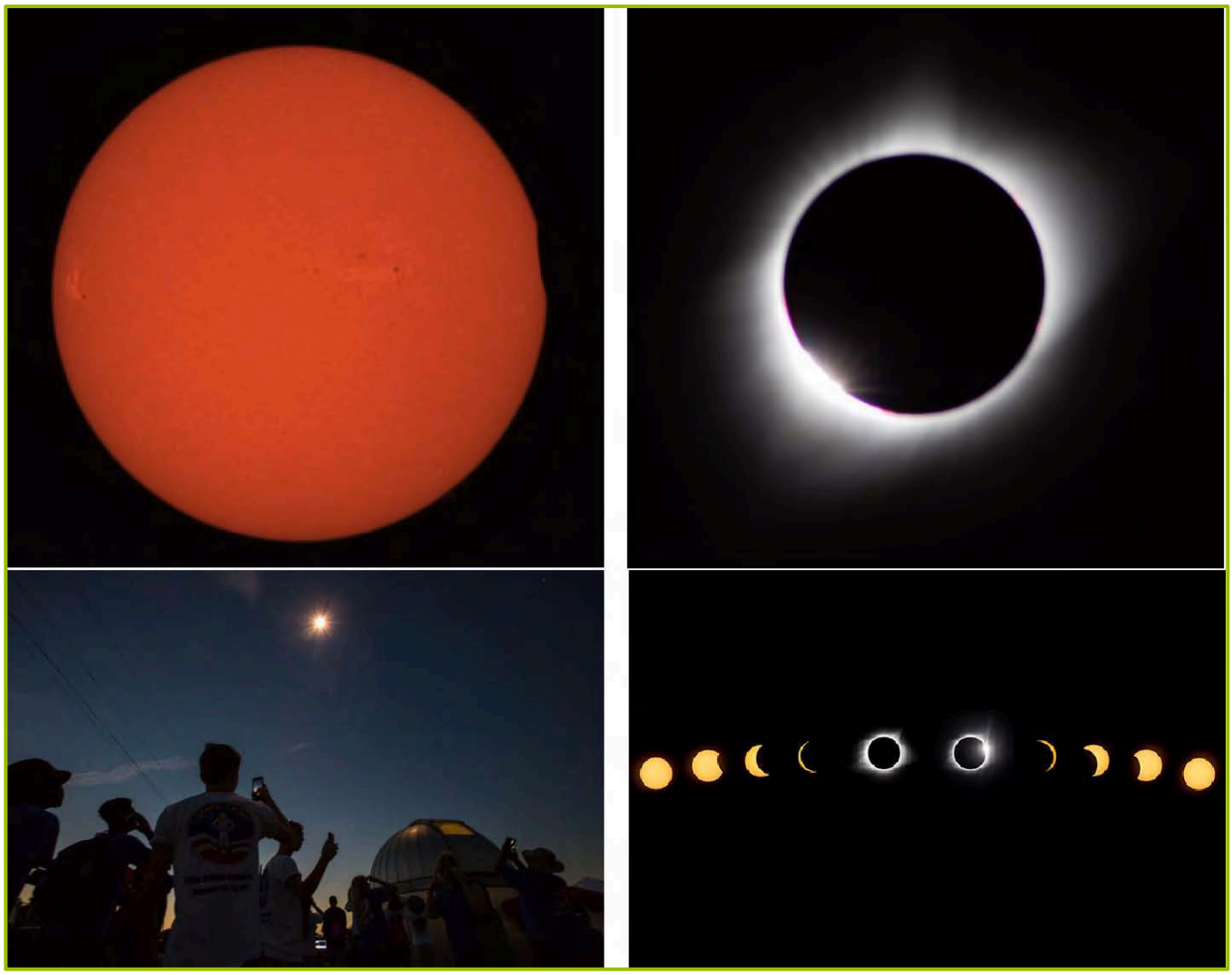

Figure 9. *Top Left: First Contact in Clarksville, Tennessee as seen in the light of H-α (see text for more explanation). Photo by Mitzi Adams, NASA/MSFC. Top Right: The Diamond Ring effect seconds before totality close to Guthrie, Kentucky. Photo by Dennis Gallagher, NASA/MSFC. Bottom Left: This image shows APSU's Observatory dome at the bottom right, as well as USSRC space campers and INSPIRE Project students. Photo courtesy Sean McCully of APSU. Bottom Right: A full eclipse sequence showing partial phases, totality, and the Diamond Ring. Photo by Debra Needham, NASA/MSFC.*

2.7 Language Arts

Often overlooked by STEAM students, language arts are extremely important for clear and effective communication. Dr. Amy Wright, professor in APSU's Languages and Literature Department, discussed the finer points of journaling with the students. Dr. Wright, whose expertise is non-fiction creative writing, stressed the importance of including memories of events that include all the senses. As examples, Dr. Wright read a journal entry from Virginia Woolf and a passage from the essay "Total Eclipse" by Annie Dillard. Writing of this type is intended to evoke images and emotions, and perhaps sound and smell as well, all the senses. From Barden Fell, north of Ilkley in England, Virginia Woolf, as a science attentive, described totality of the 1927 eclipse in this way:

> *We saw rays coming through the bottom of the clouds. Then, for a moment we saw the sun, sweeping it seemed to be sailing at a great pace & clear in a gap; we had out our smoked glass-es; we saw it crescent, burning red; next moment it had sailed fast into the cloud again; only the red streamers came from it; then only a golden haze (Diary 3: 143).*
>
> This quote is taken from a discussion of accounts of the 1927 eclipse, "Eclipse Madness, 1927" by Holly Henry, found here: https://academic.oup.com/astrogeo/article/40/4/4.17/259593)

Ms. Woolf's eclipse was shrouded in clouds with a very short totality, about 23 seconds. The red streamers, of her description were possibly solar prominences. The account of Annie Dillard reflects a familiarity with technology, and a more technical description:

You have seen photographs of the sun taken during a total eclipse. The corona fills the print. All of those photographs were taken through telescopes. The lenses of telescopes and cameras can no more cover the breadth and scale of the visual array than language can cover the breadth and simultaneity of internal experience. Lenses enlarge the sight, omit its context, and make of it a pretty and sensible picture, like something on a Christmas card. I assure you, if you send any shepherds a Christmas card on which is printed a three-by-three photograph of the angel of the Lord, the glory of the Lord, and a multitude of the heavenly host, they will not be sore afraid. More fearsome things can come in envelopes. More moving photographs than those of the suns corona can appear in magazines. But I pray you will never see anything more awful in the sky.

Figure 10. *Dr. Amy Wright of APSU gives pointers on science journaling*

You see the wide world swaddled in darkness; you see a vast breadth of hilly land, and an enormous, distant, blackened valley; you see towns lights, a rivers path, and blurred portions of your hat and scarf; you see your husbands face looking like an early black-and-white film; and you see a sprawl of black sky and blue sky together, with unfamiliar stars in it, some barely visible bands of cloud, and over there, a small white ring. The ring is as small as one goose in a flock of migrating geese if you happen to notice a flock of migrating geese. It is one-360th part of the visible sky. The sun we see is less than half the diameter of a dime held at arms length. (The quote is from the full essay posted here: https://www.theatlantic.com/science/archive/2017/08/annie-dillards-total-eclipse/536148/)

In this Journal, are more eclipse essays, written by INSPIRE Project students who were sponsored to travel to Tennessee and be inspired by viewing their first total solar eclipse.

Figure 11. *Left: Dr. Webb, INSPIRE Project's President, with INSPIRE's Program Manager Eva Kloostra, after the post-eclipse celebratory meal. Right: INSPIRE's Project's Secretary Karin Edgett poses with her eclipse glasses in the field belonging to Rudy Hall near Guthrie, Kentucky.*

3. ACKNOWLEDGEMENTS

There are so many people without whom this project would not have been possible, from the APSU staff to the U.S. Space and Rocket Center, to Marshall Space Flight Center, the Heliophysics Education Consortium (now Space Science Education Consortium), and NASA Headquarters. NASA and MSFC's Public Affairs Office worked tirelessly, and the MSFC-TV crew created an environment that made us all look good on camera. I will not call out specific names, because I know I would inadvertently forget someone. However, I do specifically thank the folks in Figure 11: Dr. Phillip Webb, Eva Kloostra, and Karin Edgett.

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About Mitzi Adams

Mitzi Adams is a solar scientist for NASA's Marshall Space Flight Center (MSFC), where she studies the magnetic field of the Sun and how it affects the upper layer of the solar atmosphere, the corona. Ms. Adams, a daughter of Atlanta, earned a Bachelor of Science degree in physics with a mathematics minor from Georgia State University. In 1988, the University of Alabama in Huntsville and NASA made her an "offer she couldn't refuse" and she moved to Alabama, where she earned a Master of Science degree in physics and began work at NASA/MSFC. With a professional interest in sunspot magnetic fields and coronal bright points, friends have labelled her a "solar dermatologist". Frequently involved in educational outreach activities such as viewing solar eclipses and transits of Mercury and Venus, Ms. Adams sometimes seeks innovative material in unusual places. While few women travel alone, she has often been seen alone and in groups in the wilds of Peru, northern Chile, Guatemala, and southern Italy.

INSPIRE 2017 Solar Eclipse VLF Field Experiment

Dennis Gallagher[1], Mitzi Adams[1], Rose Bollerman[4], Jesse-lee Dimech[1,5], Karin Edgett[3], Clark Gray[3], Colby Gray[3], Isadora Germain[3], Charis Houston[3], Nick Keesler[2], Eva Kloostra[3], Michaela Mason[4], Chris McCarthy[4], Destiny Frink-Morgan[3], Allyn Smith[2], Christopher Stephens[3], Hector Torregrosa[4]

1 NASA Marshall Space Flight Center
2 Austin Peay State University
3 The INSPIRE Project
4 US Space & Rocket Center Elite Space Camp
5 now at Geoscience Australia

Five INSPIRE Students and three US Space & Rocket Center students in an elite Space Camp program along with chaperones, parents, mentors, and neighbors gathered at a remote location on the morning of August 21, 2017 to experience a solar eclipse. The plan was to run field experiments that included: recording VLF radio noise, video taping eclipse shadow bands, testing a partial-solar-eclipse image projection tent, viewing the Sun through a 6-inch Celestron telescope, photographing the Sun with a Nikon camera and super-telephoto lens attached to the telescope, and recording the horizon during totality using a rotating camera. To accomplish our first goal of recording VLF radio sounds, our group had to be well away from alternating current (AC) electrical power, which proved to be a challenge.

The field site is only about 1.37 miles (2.2 km) from the totality centerline, which makes this an amazing find. The Tennessee Valley area, including this site, was targeted by Federal legislation in 1933 to create the Tennessee Valley Authority with the charter to develop this area devastated by the Depression. The charter included providing electrical power, so it is quite hard to find and get to any location away from the power grid. However, thanks to Kentucky farmer, Mr. Rudy Hall, we were able to make our observations from Mr. Hall's farm near Guthrie, Kentucky (Lat.: 36.743° N, Long.: 87.2124° W). Dr. Jesse-lee Dimech, a post-doctoral researcher at NASA's Marshall Space Flight Center, took the picture shown as Figure 1.

Figure 1: *Field-site between Mr. Rudy Hall's farm fields near Guthrie, Kentucky, USA. The picture is by Jesse-lee Dimech.*

The field-site was setup as shown in Figure 2. The site elements were arranged with those most visitor friendly nearest the local access road. The VLF setup and telescope/camera were farthest from the entrance to the area. We were happy to have Mr. Hall setup a tent near us so that we could easily share what we were doing with him and his family. I leave it to the reader to figure out KYBO, though it proved useful during the 5 hours or so of our visit. Figure 3 is a photograph of the site during partial phase of the eclipse. We could listen to the VLF while it was recording and mostly be preoccupied by the Sun and expectations for seeing the corona during totality.

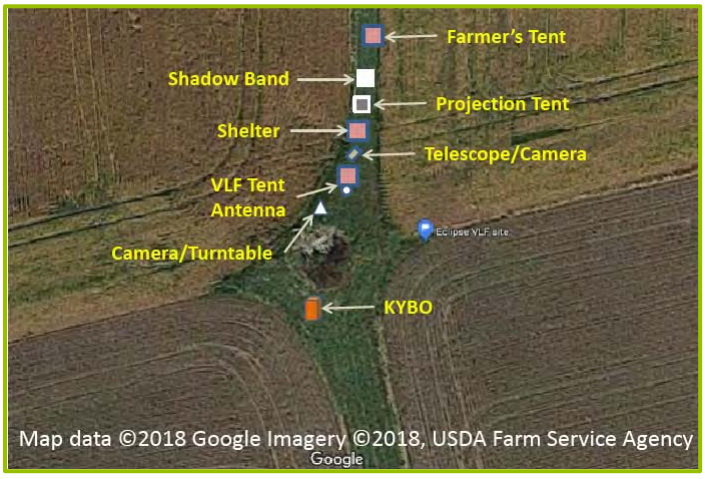


Figure 2: *Eclipse-VLF field-site layout*

Figure 3: *During partial eclipse at the VLF field-site*
Photo courtesy of The INSPIRE Project

A white sheet and tripod mounted cell phone were set up at our site, as shown in Figure 4, for the purpose of capturing shadow bands if they happen to appear. Shadow bands are thought to be caused by an atmospheric effect during about the 30 seconds just before totality and 30 seconds just after totality ends. Michaela Mason, one of our authors, used her phone to take 5 minutes of video spanning totality and was rewarded by seeing the light-dark shadow bands moving across the sheet. Because the bands have low contrast, they are difficult to photograph. Figure 4 is the result of enhanced contrast and differencing two sequential images from the video taken by Michaela. The bands visible in the difference-image reflect movement of the bands toward the camera rather than directly showing the bands as seen by an observer next to the sheet. That can more easily be shown by checking out the diagonal black-white streak in the upper-left portion of the sheet, which is caused by the blurred image of an insect that was caught flying from left to right. The white streak shows where the insect was in the second of the differenced video frames and the black streak where it was in the first.

Figure 4: *Enhanced shadow bands are shown. The original video was taken by Michaela Mason.*

The projection tent was our way to create a substitute for tree leaves during the partial phase eclipse. Sunlight passing through pinholes in a raised black sheet produced crescent images on a white sheet on the ground. Just like the small gaps between tree leaves, each hole projected the eclipsing Sun so that many could see it at the same time. A close up of a few of those projections are shown in Figure 5. A colander can also be used to create this effect.

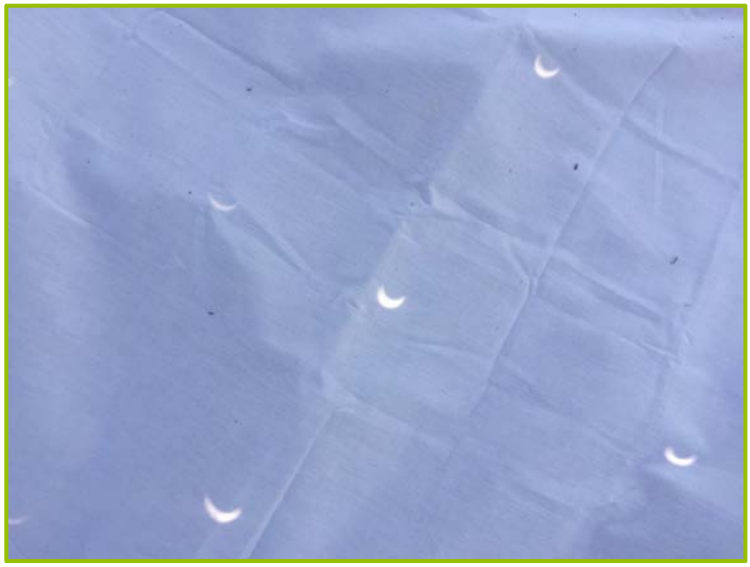


Figure 5: *Projection-tent images of the partial solar eclipse are shown. The picture is by Karen Edgett.*

As noted elsewhere in this issue, the ionosphere was expected to exhibit reduction in D-layer ionization within the path of eclipse totality. The objective of hosting a field-site for VLF observations was to engage students in testing whether those changes were enough to change the character of VLF radio noise that is normally observed at this location and time of day. Whistlers are not common at this latitude, but like most places, spherics can be observed most of the time and tweeks are not uncommon after sunset and before sunrise. Atmospheric scientists were contacted to provide lightning discharge rates within 3000 km of this location and also near the magnetic conjugate location in the southern hemisphere. There were quite active lightning storms going on south and north of our Kentucky location during the days we observed (I'll say more about that shortly). The conjugate hemisphere was not so supportive; there were only two lightning discharges during all the time we observed.

While extensive observations were not possible, we did observe at this location on August 19 during sunset. We also observed a few days later at mid-day, the eclipse time, and after sunset. In all cases, these observations were made at the same location. Figure 6 summarizes our findings.

The average lightning discharge or flash rates are indicated in the upper right of the figure. Rates are number/sec and are averaged over the full time interval of observations on each day. While there were somewhat more flashes within 3000 km on the 19th, the rate of spherics that night and two days later during the mid-day eclipse are essentially the same. The red horizontal bar on the 30 s^{-1} grid line indicates the duration of the eclipse at our site, which was 2min 39.9sec. The plots of these two rates suggest little difference between the two observing times and a possible trend, though more measurements are needed to substantiate whether the downward trend means anything. The rise in the rate of tweeks after sunset is not surprising. The suggestion that this rise mostly follows sunset by roughly 7 minutes may be the result of the ionosphere entering Earth's shadow later than a location below on the ground and continued rise may relate to the time scale of ionospheric changes after entering Earth's shadow.

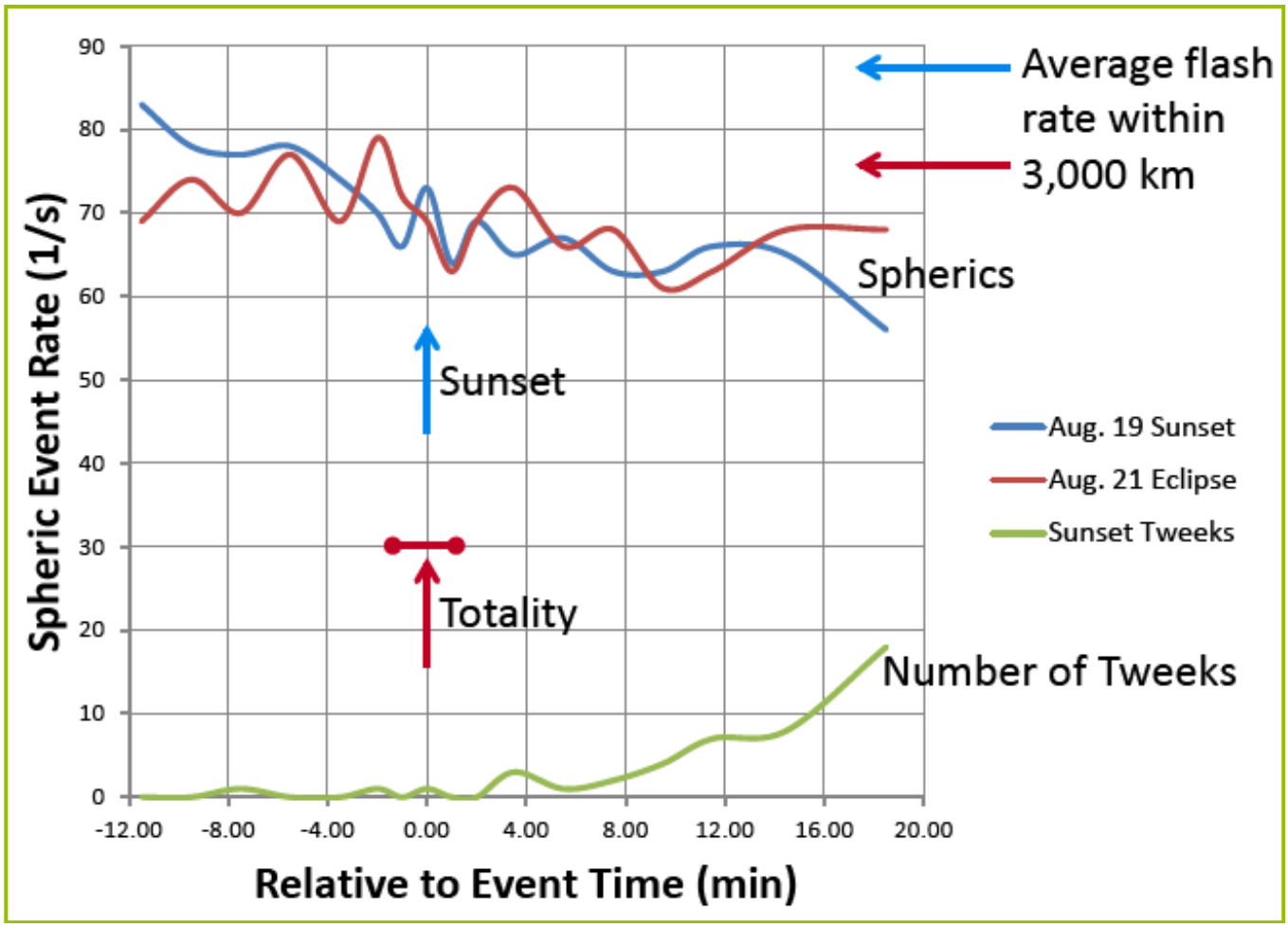


Figure 6: *Spheric and tweek rates are shown as time relative to the time of maximum totality and sunset. Blue is used for sunset measurements on August 19 and red for mid-day measurements during the eclipse. Green is used to indicate the number of tweeks/min.*

In all, it would seem that a longer period of totality might result in a measurable change in VLF noise. The longest totality time for an eclipse is about 7 minutes. Not addressed by this near-zenith solar eclipse is the possible significance of the eclipse elevation at the observing site. Some academic thought could be given to that question or… one could just travel to South America next year to check VLF radio noise during another eclipse.

One final photograph is shown in Figure 7, even if it is not as spectacular as many taken of the Sun during totality. It was a first totality photograph by Dennis Gallagher, another of our authors, that was taken with a Nikon D3300 camera using an Opteka 650-1300mm telephoto lens (1/125sec, ISO-200, RAW+JPEG). It is clear to Dennis that doing better photography is one of the cravings that drive people to travel the world to see another and yet another of Nature's spectacular shows.

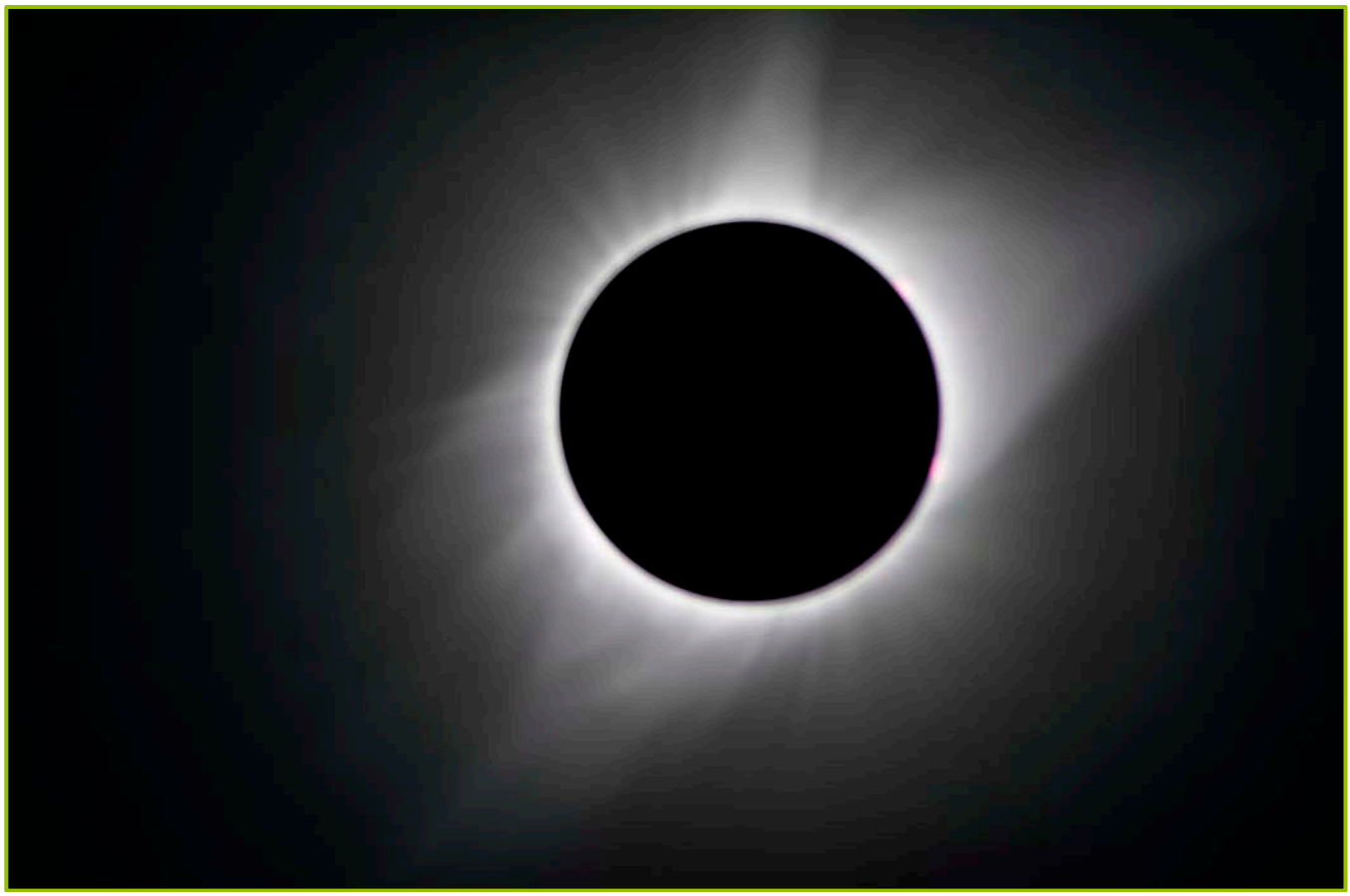


Figure 7: *The Sun's corona during totality near Guthrie, Kentucky, USA. The picture is by Dennis Gallagher.*

About Dr. Dennis Gallagher

Dr. Gallagher has worked for NASA Marshall Space Flight Center since 1984 doing research in space plasma physics. Dr. Gallagher was the study scientist for the Inner Magnetosphere Imager Mission concept that was realized in the first selected MIDEX Explorer mission, IMAGE, for which he was a Co-Investigator. He supported IMAGE mission planning and instrument requirements definition for the Extreme Ultraviolet imager and the Radio Plasma Imager instruments and has participated and led numerous studies of the measurements obtained by this first-ever magnetospheric imaging mission. He continues to be involved in the development of thermal plasma modeling and the study of IMAGE Mission observations.

Dennis at Eclipse-VLF field-site in Guthrie, Kentucky – August 21, 2017

Through the years at NASA Dr. Gallagher has led and supported a diverse variety of studies including examination of the feasibility of using electrodynamic tethers at Jupiter for orbital capture and maneuvering, for the viability of the concept of plasma propulsion, for measuring the spin of individual dust grains suspended in an electrodynamic trap in the Dusty Plasma Laboratory at MSFC, and for deriving the electrostatic charging properties of radioactive dust as it decays and fissions in support of developing a fission-fragment in-space rocket engine. From 2006 to 2011 Dr. Gallagher served as Deputy and Acting Manager for the Space Science Office at NASA Marshall Space Flight Center. Researchers performed research in Heliophysics, Planetary Sciences, Space Weather, and Astrophysics. He has returned to primarily scientific research following serving as manager of the Heliophysics and Planetary Science Office from 2011 to 2013.

Dr. Gallagher serves as INSPIRE's Chief Technical Advisor. Dennis answers The INSPIRE Projects' VLF kit user technical questions and updated INSPIRE's VLF3-b Kit Assembly Instructions in June of 2016. He has been actively involved with the organization since it was founded in 1989.

The "Peay'Clipse" Experience: Scientists from NASA, INSPIRE and Austin Peay State University study living organisms during the Great American Eclipse

Dr. Donald Sudbrink Jr.

Austin Peay State University's Farm and Environmental Education Center in Clarksville, Tennessee had the closest university observatory to the greatest level of totality during the Great American Eclipse of 2017. This APSU center hosted approximately 175 scientists, students and observers who participated in a wide variety of eclipse-related research experiments during this spectacular event. INSPIRE students were very enthusiastic and integral in assisting the conduct of several experiments including some with living organisms like cattle and insects. Several presentations and abstracts have been generated from these studies:

1.) Life at the "Peay'Clipse" and Beyond: Observations on the behavior of several organisms in Tennessee and adjacent states during the Great American Eclipse of 21 August 2017

Donald Sudbrink, Rodney Mills, Robert L. Moore, Emily Rendleman, John Fussell, Amy Wright, Mitzi Adams, Thomas Payne, Lynn Faust, Hebron Smith and Stephen Smith. *Austin Peay State University, Clarksville, Tennessee (DS, RM, RLM, ER, JF, AW, HS and SS), NASA/Marshall Space Flight Center, Huntsville, Alabama (MA), Woodlawn, TN (TP), Knoxville, TN (LF). (Presented at the Annual Meeting of the Tennessee Academy of Science, Martin, TN Nov. 17, 2017)*

Numerous organismal behaviors have been observed and recorded during previous total solar eclipses ranging from no-effects to significant alteration of diurnal behaviors. To further investigate some of these phenomena during the Great American Eclipse of 21 August 2017, a series of observations of behaviors of several species of organisms were taken in Montgomery and Knox Counties in Tennessee, Todd County, Kentucky and Rutherford County, North Carolina. Behaviors of several species of insects, reptiles, birds, mammals, and plants were observed during this event. While a few organisms showed no effects near or during the totality of the eclipse, most observations indicated at least a temporary alteration of typical diurnal behavior for each organism studied. Typical diurnal behaviors of organisms were observed to resume after totality, albeit somewhat delayed in a number of species studied.

2.) The Sun, the Moon and the insects: Influence of the Great American Eclipse on selected observed insect behaviors

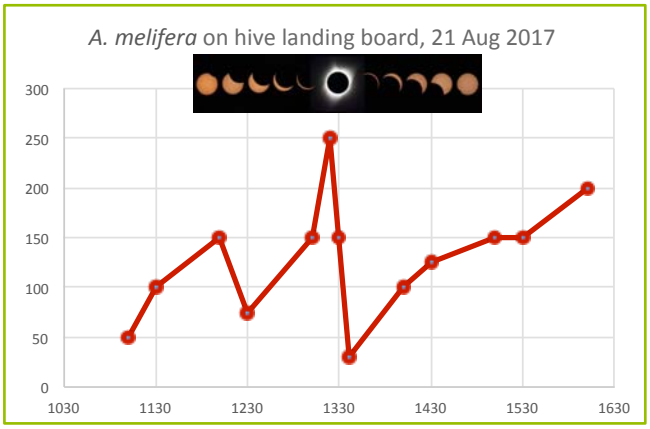
D.L. Sudbrink, Jr.$_1$, R.L. Moore$_1$, E.D. Rendleman$_1$, C.W. Galben$_1$, A.M. Wright$_2$, M.L. Adams$_3$, T.E. Payne$_4$ and L.F. Faust$_5$, $_1$Department of Agriculture, Austin Peay State University, Clarksville, TN, $_2$Department of Languages and Literature, Austin Peay State University, Clarksville, TN, $_3$NASA/Marshall Space Flight Center, Huntsville, AL, $_4$Woodlawn, TN, $_5$Knoxville, TN. *(Presented at the Annual Meeting of the Tennessee Entomological Society, Nashville, TN, Oct. 5, 2017)*

The behaviors of numerous insect species have been observed and recorded during previous total solar eclipses ranging from no-effects to significant alteration of diurnal behaviors. To further investigate some of these phenomena during the Great American Eclipse of 21 August 2017, a series of observations of behaviors of several species of insects were taken in Montgomery, Knox and Rhea Counties in Tennessee, Todd County, Kentucky and Rutherford County, North Carolina. Behaviors of several species of insects including crickets, bees, cicadas, mosquitoes, butterflies and moths were observed during this event. In the time near or during the totality of the eclipse, observations indicated at least a temporary alteration of typical diurnal behavior for each species studied. Typical diurnal behaviors of species were observed to resume after totality, albeit somewhat delayed in a number of species studied.

3.) Total Eclipse of the Bees: Effect of Solar Eclipse on *Apis mellifera*

Emily Rendleman, Robert Moore, Dr. Donald Sudbrink, Dept. of Agriculture, Austin Peay State University.
(Presented at the Annual Meeting of the Tennessee Entomological Society, Nashville, TN Oct. 5, 2017)

Honey bees and other members of the family Apoidea have been studied for many years, and one such subject area is that of solar eclipses. Much of the data collected has been anecdotal reports of honey bee behavior without much quantified support. This experiment done during the August 21st, 2017 total solar eclipse attempted to marry the quantitative and qualitative. Three hives of *Apis mellifera* were observed between the hours of 11 AM and 4 PM, with records being made of how many bees were present on the landing boards. Results have shown dramatic differences in behavior between that of a normal day and the period of totality.



- Observed and counted bees at landing boards on hives
- As totality approached, bees began rushing back to the hives
- Clustered on landing boards and hive faces
- Bees formed dark buzzing cloud, as if a hive had been dropped
- Almost every bee was back in a hive by 12 min after totality
- Didn't resume takeoffs until approximately ½-hour after totality

APSU Peay'Clipse at APSU Farm and Environmental Education Center

Don Sudbrink discussing insect behavior with students. Rod Mills assisting INSPIRE student with spray painting numbers on cows to track behavior during the solar eclipse, while being filmed by NASA-TV

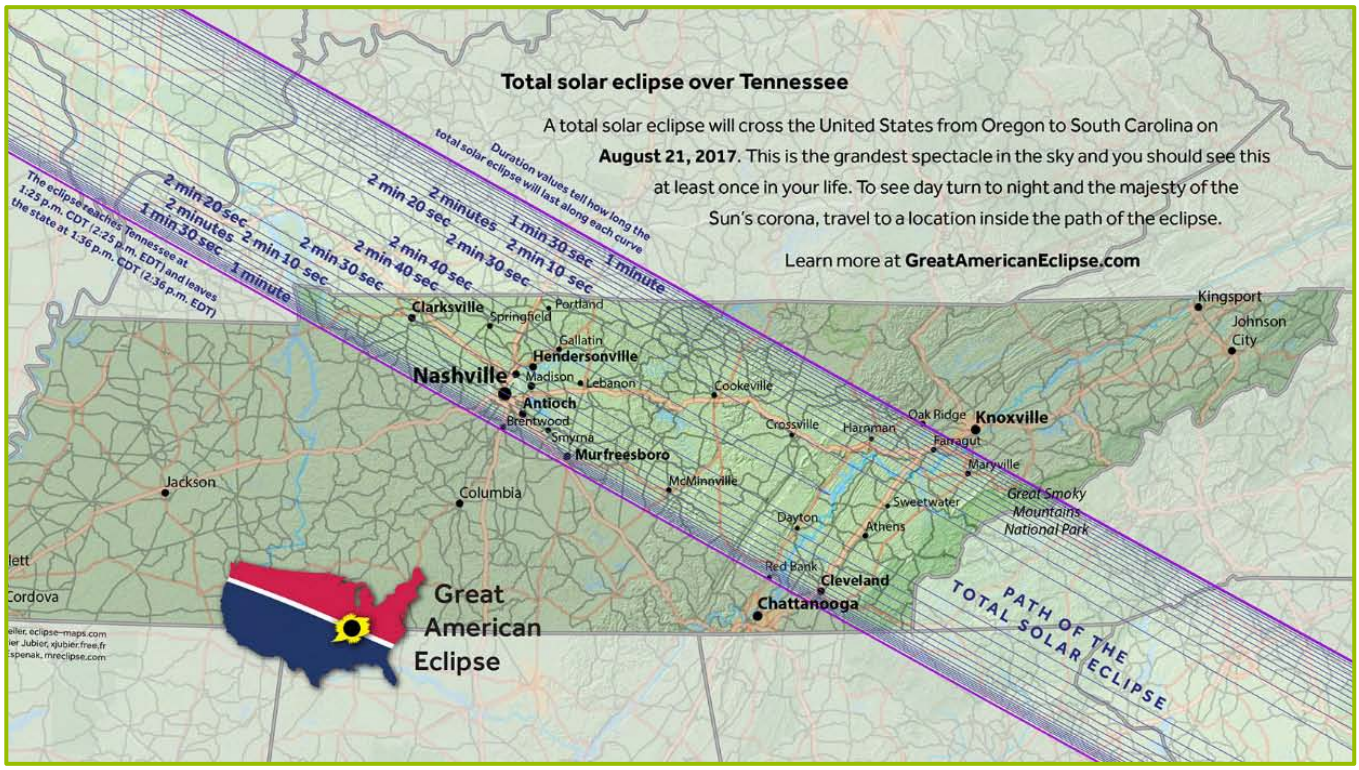
Overview

- Official NASA site, live worldwide on NASA-TV and C-SPAN
- Astronomers, Solar Physicists and Atmospheric scientists from APSU, NASA and other institutions ran a battery of physical science experiments
- 65 Students from NASA Space Camp and INSPIRE came to Clarksville for a research education experience

Objectives

- Help NASA students study animal behaviors before, during and after the eclipse in the eclipse zone
- Observe and record male cricket calling and other behaviors
- Observe and record honeybee behaviors
- Compile observations of behaviors of other insect species from collaborative observers in the zone of the eclipse

Materials and Methods Observation Locations in TN, KY & NC



Collaborative Observations

Montgomery Co., TN (totality = 2min. 18 sec.)

- Field crickets were observed to chirp at totality
- Calling cicada species changed
  - a) one species called before totality
  - b) another species called during totality
  - c) previous species returned to call after totality
- Mosquitoes bit NASA researcher at APSU Farm during totality
- Four butterfly species recorded on butterfly-bushes before totality
- Monarch, Tiger swallowtail, Pipevine swallowtail, Painted lady-disappeared
- Honeybees raced back to hive and stayed inside for 1 hour
- Barred owls called at totality

Todd Co., KY (totality = 2 min. 30 sec.)

- Snout butterflies swarmed and lit on sweaty NASA INPSIRE participants at field study site before eclipse. Disappeared at totality, but returned approximately ½ hour later.
- Moths flew at totality, but did not fly afterwards.
- Chickens returned to their coop and stayed for ½ hour

Knox Co., TN

- Male fireflies (*Photinus pyralis),* flashed near-totality
- Lynn Faust et al. will publish a scientific note on firefly study soon in *Entomological News*
- Calling cicada species changed over
  - a) one species called before totality
  - b) another species called during totality
  - c) previous species returned to call after totality
- Field crickets chirped at totality

Snout butterfly on INSPIRE Educator Chris Stephens prior to the eclipse

Collaborative Observations continued

Rhea Co., TN

- Field crickets were observed to chirp at totality

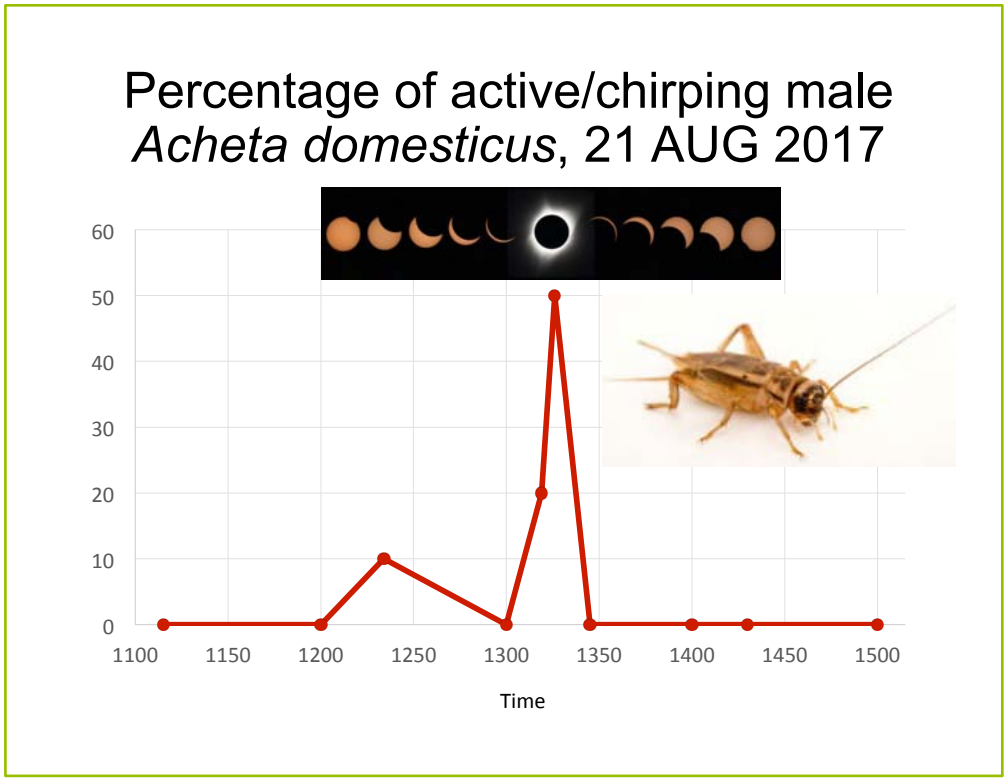
Rutherford Co., NC

- Honeybees raced back to hives at 99.7% eclipse
- Stayed in hives for more than ½ hour

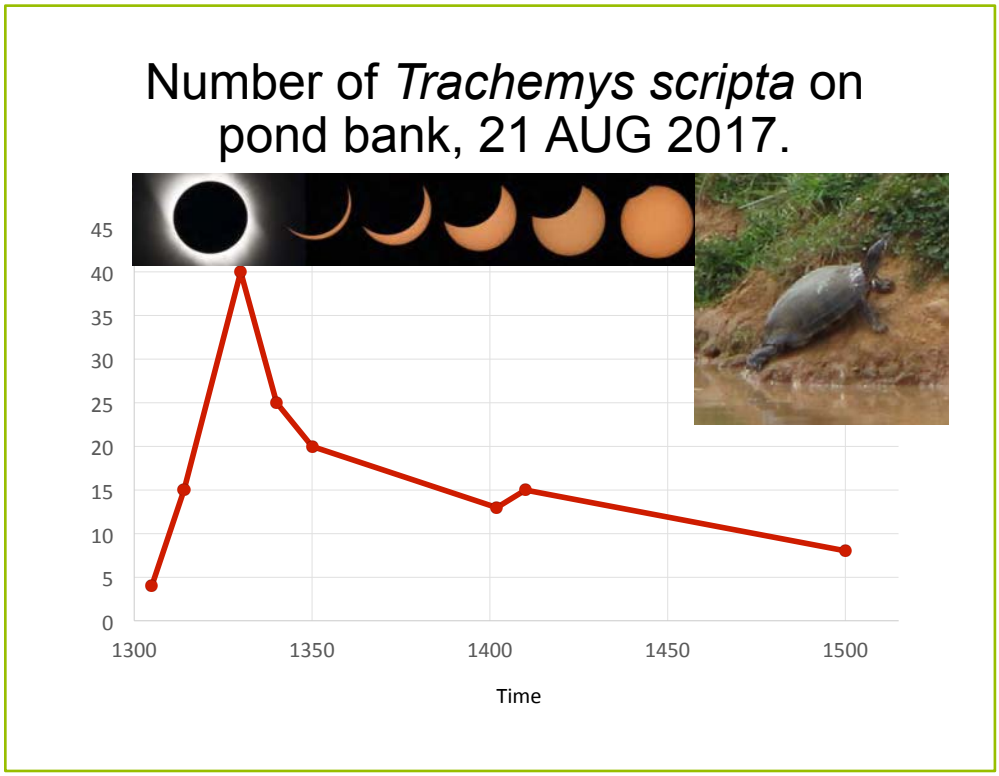
Space Academy students observe cricket behavior before, during and after the total solar eclipse at APSU farm.

Cricket Study – APSU Farm EEC

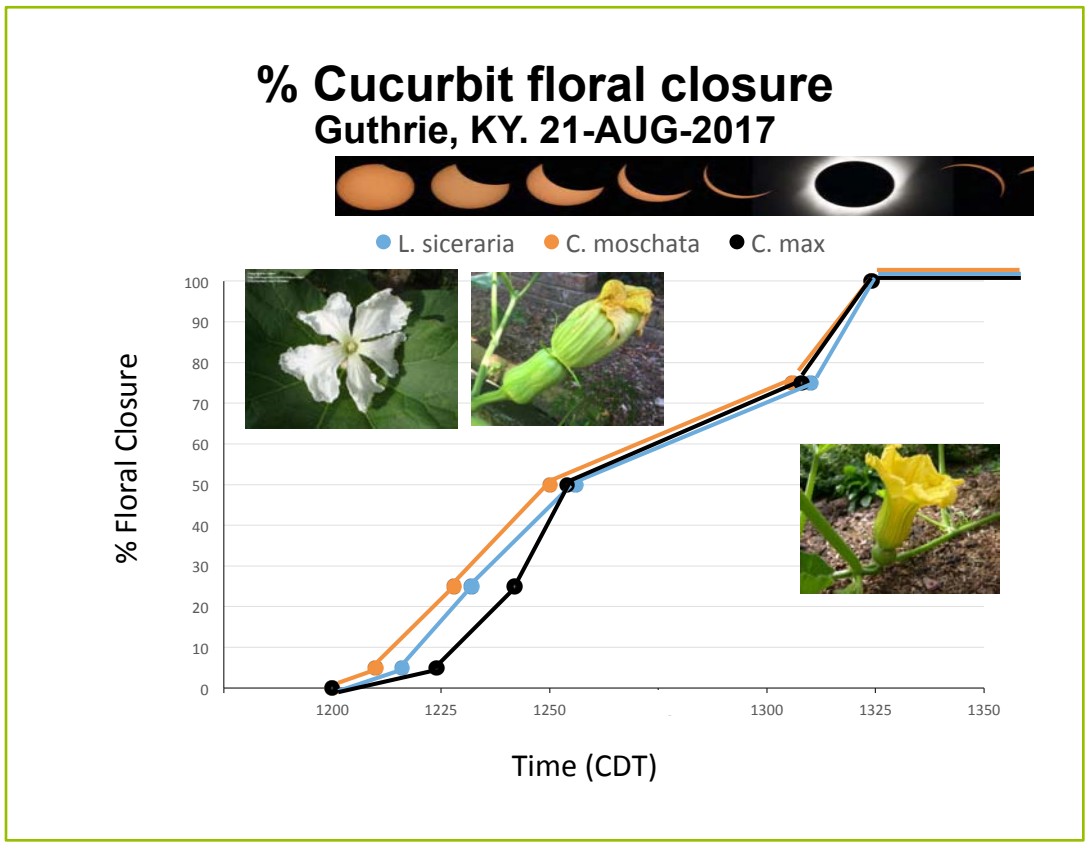
- Ten fresh male *Acheta domesticus* were each placed in cages
- Behaviors: chirp, explore, jump, climb, groom, and resting
- Prior to eclipse, *A. domesticus* observed in resting mode
- Five minutes before totality, 20% started to chirp
- At totality, 50% of crickets chirped and/or actively explored containers
- Crickets stopped chirping at totality's end and remained in resting mode for duration



Turtle Observations – APSU Farm EEC

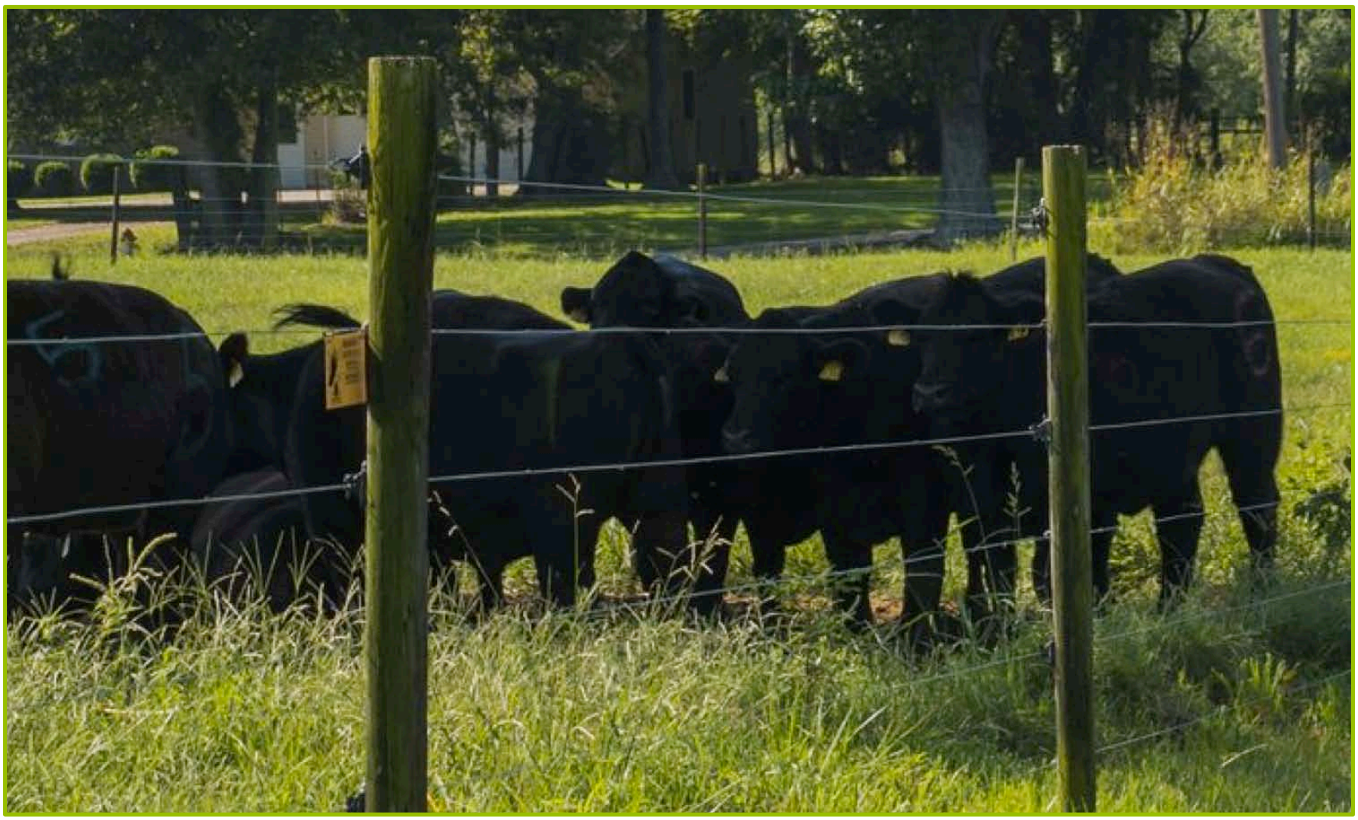


Plant Observations – APSU Farm EEC



Cattle Observations – APSU Farm EEC

Dr. Rod Mills reported that one cow went out to graze during totality and returned.



SUMMARY

- A series of organismal behaviors was observed during the Great American Eclipse in TN and adjacent states including mammals, birds, reptiles, insects and plants
- Several species altered their typical diurnal behaviors
- Honeybees returned to hives at totality and stayed inside for at least ½ hour
- Crickets - 50% of *Acheta domesticus* males were chirping and or active during totality, but returned to resting shortly after eclipse
- Cucurbit flowers had closed by totality and remained closed
- Only one cow went to pasture and grazed at totality

Dr. Rod Mills discusses cow behavior with Space Camp and INSPIRE students in the Environmental Education Center

About Dr. Donald Sudbrink Jr.

Dr. Donald L. Sudbrink Jr. is Chair of the Department of Agriculture at Austin Peay State University and runs their Farm and Environmental Education Center where, each year, he hosts the Summer Science and Math Academy for high school science students.

He received his B.S. in Entomology-Plant Pathology from The University of Delaware, and M.S. in Entomology and Plant Pathology from The University of Tennessee. Dr. Sudbrink received his Ph.D. from Auburn University in Entomology.

The Boy Who Noticed the Watermelon Flowers

Dr. Amy Wright – Austin Peay State University Professor, Writer

The coming shadow pushes a welcome breeze under the ninety-six-degree air before it. NASA researchers, joining others positioned across the eclipse path from Oregon to South Carolina, launch their last two balloons. They swell before a news crew like Lady Liberty's blown bubblegum, with boxes in tow to gauge air-pressure and temperature in the Martian-like atmosphere of the stratosphere. One also hefts a camera. The other dangles microbes found living like barnacles outside the International Space Station. A balloon released that morning had failed. When we see the second parachute open and a tail of boxes sail down in the distance, Douglas, a team leader, says: "Good thing they didn't catch that on film," since the C-Span reporters have turned their attention elsewhere.

Photo courtesy of Gregory "Slobirdr" Smith

I am surrounded by twelve- to sixteen-year-olds who use words like "declination" in casual conversation. NASA's live feed is being shot from the astronomical observatory on our university's working farm and environmental center, and I volunteered to help INSPIRE and NASA Space Camp students journal their experience.

Some of the students are monitoring beef cattle to see if they leave the shade of the trees when the sky darkens. Others, which entomologist Don Sudbrink calls "The Cricketeers," are marking boxes of male crickets to determine if they call for females, or chirp, during totality as they normally do at night. Beekeepers Bob Moore and Emily Rendleman are setting up a station by the beehives to see how honeybees respond since they navigate by the Sun.

The ancient Chinese blamed a dragon for devouring the Sun, so the Chinese word for eclipse is *chih*, to eat, but I wait my turn at the telescope in a wheel of chatting people as if feeding coins in for a peep show. The Sun being taken by this dark body is public as a mall poster of tantric union, Sparshavajrā's head thrown back in abandon. I scrutinize each meeting point, under magnification.

When the last gleaming crevice between them squeezes shut, we tear off our shades and fill our eyes. A chorus of shouts goes up. In one 1,450-m.p.h. wave the Moon's shadow has stranded islands of people in a sea of evenfall. "Where in your body do you feel awe?" I had asked students earlier, "Your stomach? Toes?" My cheeks stream with tears, exposed emulsion paper dipped in a silver bath.

Skin tones glow indigo and a kit of rock doves swoops overhead. The corona flexes and flails, wild haired behind the curtained spotlight. I turn and scan the horizon, the only celestial modesty for 360 degrees its downcast lavender lid.

Photo courtesy of The INSPIRE Project

When the Sun reemerges flushed and bright-eyed, solar physicist Mitzi Adams wastes no time assembling observations from these two minutes and eighteen seconds none of us alone can comprehend.

Photo courtesy Sean McCully of APSU

"I had to step back ten feet," says Emily, "The bees were jostling each other off the hives' landing strips, buzzing in agitation rather than their usual hum."

"At least two mosquitoes came out," according to Mark pointing to stings.

The Cricketeers report that four boxed crickets sung and were joined by more in the wild. They also saw fifteen then twenty, then forty eastern sliders pop out of the pond to bathe in the twilight. One cow began grazing, Rod notes. Masu saw a crow change flight.

"The plants think it's a new day," José says, having seen the watermelon flowers, which open for one day only, close when the temperature and light fell. He was not surprised that they did not reopen, because he raises his own watermelons as well as peas, pumpkins, and chilies. The female flowers had had their morning. They unfurled yellow petals, beckoned honeybees in ultraviolet radiance to their swollen stamen, and waited. Grains of pollen dropped and clung to the lucky ones. For the others, it was over. The chance had passed by them like an empty hand. Providing our only plant observation, José was the first person to document that phenomenon.

"He's exceptional," we agree at dinner.

As is this planet, optical physicist Phil Stahl explains: "Without the Moon's sway, Earth's distance from our G-class star would not have been enough to evolve life." The ebb and flow that the Moon generates pulls the ocean into rock shallows, which the Sun warms. It is a recent observation about the importance of tidal pools, he adds, but it makes sense that marooned until high tide species have long teemed together and schooled each other, leaving each one better for it.

I picture Spring Break hot tubs. For all our mathematical abilities to predict eclipses until this Saros series, or season, ends in 3009, we are testaments first to hot-bloodedness. The animal scientists, whose own circadian rhythms have been jangled by eclipse fervor, will soon head back to their fields and laboratories to rejoin those creatures who low and call to each other. Those members of our cohort who will pore tomorrow over footage of solar winds and magnetic fields recognize the remarkable nature of this conjunction. Those who will commence mapping the universe appreciate the odds not for life but those against it. In the midst of political discord and ecological turmoil, they wonder at the billions of years that have led to this alignment. Kind of makes a person want to nuzzle up to a loved one, the star-studded sky above this habitable zone nothing short of expectant.

About Dr. Amy Wright

Amy Wright is the author of Everything in the Universe, Cracker Sonnets, and five chapbooks. She also co-authored Creeks of the Upper South, a lyric reflection on waterways and cultural habitats. Her writing has been awarded two Peter Taylor Fellowships for the Kenyon Review Writers' Workshop, a fellowship to the Virginia Center for the Creative Arts, and an Individual Artist's Fellowship from the Tennessee Arts Commission. Amy Wright is a Professor and the CECA Coordinator for Creative Writing at Austin Peay State University.

Austin Peay State University – Clarksville, TN

INSPIRE Space Academy Alumni Students' Total Solar Eclipse Experience & Observations

Eva Kloostra, INSPIRE Program Manager

Since the launch of INSPIRE's Space Academy for Students program ten years ago, it has been a dream of mine for the elementary and middle school students who received scholarships to attend the weeklong STEM program to have a similar opportunity as high school students to further reinforce his or her STEM education and future career path. This dream became a reality for 12 amazing alumni students in August 2017. Mitzi Adams and Dennis Gallagher of NASA Marshall Space Flight Center invited INSPIRE's alumni students to participate in hands-on field research before, during and after the total solar eclipse at Austin Peay State University in Clarksville, Tennessee. The INSPIRE Project sincerely thanks Mitzi and Dennis for everything they did to provide the students with this truly once-in-a-lifetime STEM opportunity. INSPIRE would also like to thank our generous donors, volunteers, dedicated parents, and the countless NASA and Austin Peay State University staff who helped to make this program possible. A special thanks to Kathrine Bailey at APSU and Jacquie LaPergola for their endless assistance with INSPIRE's travel and housing logistics.

After months of anticipation, on Friday, August 19th INSPIRE's students arrived at Reagan National Airport in Washington, DC to embark on a STEM experience of a lifetime. Though the team was ready for lift-off unfortunately the airline was not. They informed our chaperones that the students' flight was cancelled and they could not get them on another flight to Tennessee until Monday due to the number of cancellations. Fortunately one of the student's parents, Beverly and James Thomas, had a personal contact with a charter bus company and 3 hours later the INSPIRE team was en route to Clarksville.

The students arrived early Saturday morning at Austin Peay State University and got settled in their dorm rooms, which provided them with a college-life experience. After breakfast at the university dining hall, the group was off to the Austin Peay Environmental Center and farm.

Students at Reagan National Airport with volunteer Robin Houston

NASA's Mitzi Adams developed the total solar eclipse program agenda with Austin Peay staff that included the following interactive presentations at the farm on Saturday and Sunday:

- Journaling and Science Writing – Dr. Amy Wright
- Overview of Eclipse – Mitzi Adams
- Insects Likely to be Affected by the Eclipse – Dr. Donald Sudbrink Jr.
- Animals Likely to be Affected by the Eclipse – Dr. Rod Mills
- Photosensitivity and Behavior of Plants – Dr. Carol Baskauf and Josh Kraft
- Solar Viewing and Citizen CATE – Dr. Allyn Smith, Mitzi Adams, Dr. Spencer Buckner & Dr. Dennis Gallagher
- INSPIRE and VLF Radio – Dr. Dennis Gallagher
- Biological Changes Associated with Rapid Light Intensity Reduction – Dr. Karen Meisch
- Atmospheric Science Experiments – Dr. Pete Robertson
- Shadow Bands – Dr. Phil Stahl

After learning about the various eclipse research projects via the on-site presentations combined with a series of interactive online presentations that the students participated in during the months prior to the eclipse, students selected which research project they wanted to join based on his or her interest.

The students returned to campus for dinner and then were off to the secondary eclipse research site – a soybean farm in Guthrie, Kentucky 30 minutes away. Due to its remoteness and distance from power lines, the soybean farm site was used to conduct very low frequency (VLF) natural radio observations using the INSPIRE VLF receiver before, during and after the eclipse. Dennis Gallagher provided the students with an overview of the receiver and they participated in hands-on observations and experienced the sounds of space firsthand.

On Sunday morning, INSPIRE's Board President Phillip Webb arrived with his three oldest children to join the INSPIRE team. Dr. Rod Mills asked INSPIRE's students to assist his research team by spray painting numbers on the APSU cows at the farm so they could be tracked during the eclipse. NASA-TV filmed the students and the footage aired for several days as part of NASA's total solar eclipse national coverage.

Later that morning, the students from the U.S. Space & Rocket Center in Huntsville, Alabama who were also invited to participate in the solar eclipse research arrived at the farm. All of students had the opportunity to view the sun through the NASA and APSU telescopes and the remaining presentations were held.

After a full day at the farm, the students returned to campus for dinner followed by a presentation by NASA astronaut Rhea Seddon at APSU's Dunn Center and a multimedia presentation on the outside of the center entitled "Launch" which simulated the space shuttle launching.

NASA/MSFC's Mitzi Adams presenting an Overview of the Eclipse to students at APSU's Environmental Education Center

NASA/MSFC's Dennis Gallagher at soybean farm in Guthrie, KY conducting VLF observations with the INSPIRE team Saturday at dusk

On Monday morning, aka “Eclipse Day”, there was not a cloud in the sky. Excitement filled the entire town of Clarksville, Tennessee and the population doubled in a matter of hours. After breakfast, INSPIRE’s students broke off into two groups. Five of the students travelled with Dennis Gallagher and INSPIRE’s chaperone Karin Edgett to the soybean farm in Guthrie and the other seven students went with Mitzi Adams to the APSU farm.

When our group arrived at the farm, the students began working on their research projects after a final review on safely viewing the eclipse. There were camera crews everywhere and NASA-TV was broadcasting live. This serene farm was now full of energy from enthusiastic spectators. Only a few hours until the big event.

In the first classroom presentation on Saturday on the topic of *Journaling and Science Writing*, Dr. Amy Wright encouraged the students to be aware of all five of their senses during the eclipse and not just focus on sight. As you will read in the student observations, the total solar eclipse touches all of your senses and was truly spectacular.

At the end of the day, the students were reunited for an INSPIRE celebration dinner to compare their experiences. The next morning the students arrived at Nashville airport to learn that once again their flight had been cancelled (really!). Fortunately, they safely returned home the following day via another flight and got to spend a fun day in Nashville. At the airport, they ran into NASA astronaut Mark Kelly and his wife Gabby Giffords who posed for a photo with them – a perfect ending to a once-in-a-time experience for 12 extraordinary DC high school students.

INSPIRE students at APSU the morning of the total solar eclipse

Mitzi Adams (center) with APSU staff at INSPIRE’s total solar eclipse celebration dinner on Monday night

INSPIRE students at the Nashville airport with NASA astronaut Mark Kelly and his wife Gabby Giffords

(Left) INSPIRE students Nile, Joshua and Robert viewing the eclipse Eclipse photo courtesy of APSU’s Hunter Abrams

INSIPRE Student Observations: Soybean Farm – Guthrie, KY

Five INSPIRE's students participated in hands-on research before, during and after the total eclipse with Dr. Dennis Gallagher of NASA Marshall Space Flight Center on a local farmer's soybean farm. This remote location was selected to conduct VLF observations using the INSPIRE receiver to avoid interference from power lines. Pictured left to right: Isadora Germain, Clark Gray, Destiny Frink-Morgan, Charis Houston and Colby Gray

Total Solar Eclipse 2017 – Charis Houston (11th Grade)
Rows of soybeans, stretching miles across the horizon, was the backdrop for one of the most incredible experiences in the past thirty-eight years. It has been thirty-eight years since the US has seen a total solar eclipse and will be seven years before another one crosses the country. The mood of the handful of expectant researchers and viewers standing knee deep in bean plants was…jubilant!

The soybean field was the best place to see the eclipse because it was isolated from where a majority of the people would gather to see the eclipse. It was also far enough from power lines that the experiment, which dealt with very low frequencies, could be conducted without electrical interference. The experiment was important because it was designed to see when lightning bolts strike, whether or not it would be heard. The best time to normally hear the lighting is between nighttime and dawn. The experiment focused on a specific radio channel from Colorado that is typically heard in the evening to see if it could be picked up during totality. Sadly, that radio channel was not heard.

The moment the moon first touched the sun was hardly noticed. None of the animals or people reacted; the scene, still was "daytime." As the moon

On Saturday evening prior to the eclipse, Dennis Gallagher set up the INSPIRE VLF receiver to conduct observations at sunset with the INSPIRE team. Charis and chaperone Chris Stephens pictured with Dennis.

began to displace the sun, some of the insects started to quiet down and go back into the bean fields where they live. When it was 10 minutes from totality, the scenery outside was almost as if color itself from the plants and trees was draining into this grayish hue. It was as if color itself was melting away when the moon was getting closer to blocking the sun.

The excitement of watching the eclipse eclipsed the ability to focus on the monitor that picked up the frequencies once the moon moved into place. It was as if time itself had stopped. The murmurs of the people standing around, watching the eclipse, becoming at once…silent. The crickets and other insects were no longer making noise. In totality, the area looked like a scene from the Twilight Zone. With a 360° sunset, it felt unreal as if it were a dream. During this time, the only animals/insects that were out were butterflies, which was very odd.

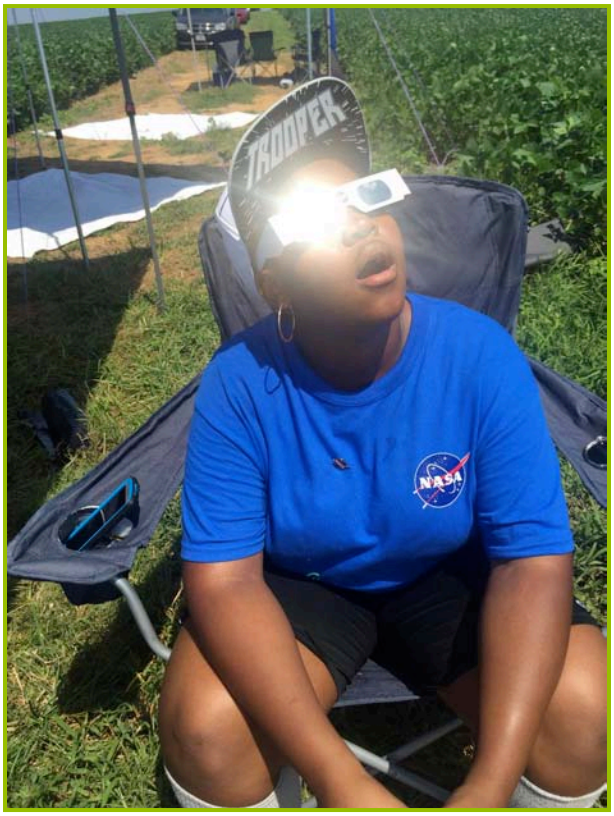
There was a period of identifying all the different phases of the eclipse. Someone blurted out “The Diamond Ring” phase and the group whooped in awe. The six-day trip can be summed up in two minutes and 40 seconds. The experience of a lifetime that will never be forgotten nor eclipsed by any other events in nature!

2017 Total Solar Eclipse in Kentucky – Clark Gray (11th Grade)
We arrived at the soybean field study site in Kentucky and it was extremely hot, but exciting. Once there, we quickly set up camp. We then proceeded to make holes in a sheet for the viewing of mini eclipses. We also set up the communications pole to observe radio frequencies during the eclipse.

After we set up, we frequently looked up at the moon's progression to the sun. While we waited, we looked at the sun through telescopes and took pictures. I found the paper viewing glasses to be ineffective as they would not fit over or under my regular eyeglasses so, I fashioned DIY goggles by taping welder's glass to my regular eyeglasses.

While observing the local insects and animals, we noticed birds flying in large swarms and the crickets coming out of hiding. The sun stayed very bright up until about 10 minutes before totality. Right before totality, all around us the colors began to dull, becoming greyish. By this time, our camp was being visited by local farmers and passersby. We struck up conversation and told them why we were here and what we were doing. They were very impressed and even took pictures with us NASA scientists. During totality, the view was an absolutely beautiful 360 degree sunset. During this time, several people sang the song “Our God is an Awesome God”. People were taking videos and pictures and walking around in awe. We took more observations and then about an hour after totality, we packed up and left.

Isadora Germain (12th Grade)
It was an honorable death. The last burst of light escaped from behind the Moon and the Sun finally closed its massive eye. My eyes adjusted and I was on an entirely different planet. An earthquake grew up from my feet, into my hands, and out through my eyes. The tears formed almost as if they wanted to witness the event for themselves. It felt like being underwater, but at the same time taking my first breath of fresh air. My other senses shut off, opening my eyes to new colors, sensations, and emotions. Left in place of the Sun was the deepest shade of black I had ever seen. The halo of light around it throbbed like my heart was racing, bringing new life to the solar system around me. I had found extraterrestrial life, but not in the way most people would think. For two minutes and 39 seconds, the moon was more alive than ever. She had a pulse. She had hands. She was grasping onto our thin atmosphere in a struggle that left rich shades of orange and red all around the horizon. I was witnessing a hello. I was witnessing a goodbye. All of a sudden, the bright and familiar warmth was back. The Sun took back its throne and the Earth began to rotate again.



Only in America - 2017 Eclipse – Colby Gray (10th Grade)
I was really glad to be selected by The INSPIRE Project for this once-in a-lifetime opportunity to view the solar eclipse in the path of totality from a Kentucky soybean farm. It was amazing and something very difficult to put into words.

Austin Peay, the university which hosted the INSPIRE group was where we had our presentations to decide which group we wanted to do research in. The options were observing the beef cattle's activity, observe the insects and observe totality from a Kentucky soybean farm. From the 12 of us, 5 of us went to the farm.

There we set up all the equipment for viewing the eclipse, such as the radio wave station, which was a frequency pole to measure the sound of lightning and other natural occurrences. We also created a tent with a tarp on top with holes poked in it so we could see the shadow bands during the different stages of the eclipse. Moments before the "Diamond Ring" effect, we could experience the environment transforming into a quiet dream setting with a 360° sunset. It was like nothing I've ever seen.

When I felt the temperature start to drop I knew it was seconds away, coming and disappearing as quickly as a fiddler on the roof. During totality we took off our glasses and viewed the monstrosity that is the moon covering the sun for two and a half minutes. As our very limited time came to an end, we put our glasses on and stood in awe. It eventually wore off and we were finally able to discuss what had just happened. Although the eclipse was not over for another hour, we all decided that nothing could compare to what we had just seen.

When the eclipse came to an end, we started to pack up as our journey was nearly over. When some local farmers had come over to see what had just happened and started asking questions and facetiming relatives because of our association with NASA, I felt like a celebrity. We got back to Austin Peay to meet up with the other groups and compared experiences and environmental observations. It was truly an honor to get to work with Mitzi Adams, Dennis Gallagher and Eva Kloostra.

Eclipse Experience – Michaela Mason
(11th Grade, Space Academy Student from England)

On the 21st of August of 2017 I was lucky enough to attend The Great American Eclipse within the path of totality. The day began in an excited rush of participating students milling into their respective groups, I contributed to a VLF group that drove out of Clarksville and into Kentucky. Being part of this team allowed me to do a multitude of projects during the hours leading up to the eclipse. These included building a pinhole tent, preparing an area for viewing shadow bands, and ultimately running the filming of the shadow bands. During these initial hours the team up in Kentucky worked together to build up the projects listed above as well as the VLF radio tower and equipment. The upcoming eclipse had everyone very excited and very willing to help. As the eclipse began, the moon moving to slowly start covering the sun, activity quieted down a bit as we all stopped to admire the oddity of what was happening. I spent time journaling the day's events and my own thoughts as a sort of distraction, all the while checking on the moon's progress.

During the final hour of totality I began to set up the necessary equipment needed to film the shadow bands we were all hoping to see during the thirty-seconds prior to and after totality. I must admit that while I did desperately want to see the shadow bands, I doubted that I would due to the fact that they are not always visible. In the final twenty minutes or so leading up to totality the atmosphere around our little team began to change. The colors of the surrounding fields became muted mellow tones, very different to the previous vibrancy of the area. As the sky grew darker there was a very welcome drop in temperature, noticeable to all who were in the area. And then in those final thirty-seconds leading up to totality I began to notice the faintest of lines drifting across the sheet that I had so carefully placed on the ground. The shadow bands!

In seeing them I remember that my heart began to race at the realization of what I was about to witness. An event I had been preparing for months, and been waiting for even longer. Suddenly, as the totality began, I looked up from the shadow bands

and found myself surrounded by a sunset on all sides. It was as if our little corner of the world had a bowl placed over it, but light was still able to escape in through the edges. I took a deep breath and looked up at the eclipse itself. I can tell you now that in reading countless witness accounts of what it would look like, I had always imagined the eclipse to hold an awesome beauty but to this day I do not have the words to appropriately describe what it looked like or how it felt to witness it. I remember noticing how the eclipse wasn't just a contrast of black and white, tones of deep blues and pastel purples swirled in a multitude of combinations, the remaining light was a light cream sort of color completely unlike its usual orangey glow. There was a sense of the uncanny, of recognizing this event but not understanding it or knowing enough about it to appreciate it. I remember twirling in place, trying to get a view of as much as I possibly could in the time I had left. I felt this urge to look around me at everything I could. The eclipse itself was part of that experience, not all of it. It was interesting to watch the reactions of others as we stood in something that resembled silence but wasn't as cold or as lonely. Time raced on at an impossible speed, it was nothing like I had ever witnessed before. As soon as I had looked up it seemed to end, and I once again found myself looking into the sun's blinding light before moving quickly to look back at the shadow bands before they disappeared.

As soon as totality ended so did the silence, exclamations of surprise and awe filled the air as we watched the moon move on and away to the next group of eclipse watchers. In a daze I finished up my filming, disassembled the equipment and began to journal my thoughts. Later that same day, as we drove away from the farm I remember feeling a sense of emptiness because the anticipation and excitement for the eclipse was gone and now replaced with a sense of longing to go back and witness it again. Now as I write this, however, I find myself with a renewed sense of excitement at the idea of the approaching eclipse on April 8th, 2024.

INSIPRE Student Observations: APSU Environmental Education Center & Farm – Clarksville, TN

Solar Eclipse Observations – Robert Allsbrooks IV (11th Grade)
This summer, I had a once in a lifetime opportunity to observe the solar eclipse with NASA scientists through the INSPIRE Project. I was one of 12 students invited to assist scientists with their research on the effects of the total solar eclipse. We stayed at Austin Peay State University, which was a location in the area of totality.

Our research focused on HAM Radio, cricket behaviors, watching animals, launching weather balloons, and looking for stars. My group worked with the weather balloons, observing cricket behaviors, and listening to the HAM Radio. The main goal of researching these activities was to see how they were affected by the solar eclipse.

When I was working with the weather balloons we were checking to see if the amount of radiation would change once the sun was hidden. We filled each of the balloons with air and then added a scientific payload to track how much radiation was in the atmosphere before the eclipse. Slowly, as the time for the eclipse came, the radiation decreased more and more. During totality, the amount of radiation was at its lowest point. After totality, we expected the amount of radiation to slowly regenerate, but instead it skyrocketed immediately back to its normal point. Another project I worked on was with the HAM Radio. For the project, we checked to see if the radio received nighttime signals during the eclipse. We set up the HAM Radio beforehand, but since no one there had a HAM license we could not send any messages. During the eclipse, we did not receive any nighttime signals during the eclipse. Our prediction was correct.
The last project I worked on was to see if the amount of chirping increased from crickets during the eclipse because they usually chirp at night. Crickets usually chirp because they are trying to attract a mate or to intimidate another male cricket. We wanted to see if they would try and do either of these actions as it got darker. During the eclipse the crickets did chirp, as if it were nighttime. As the sun slowly came out the chirping decreased and eventually stopped.

The INSPIRE Project gave me the chance to see the eclipse in the area of totality. I remember it so clearly. The sun was so bright and in a matter of seconds it was gone. The entire area was pitch black. Then a few moments later the moon was surrounded by a ring of white light. I heard a lot of Ooo's and Ahhh's, and everyone was talking about how scary the sun looked. The sun appeared to be dark as night, and the air around me got cold. I had to keep telling myself it was 2:30 in the afternoon. After about two minutes, we saw the diamond ring, and the sun was back, bright as ever. I will never forget it. After the eclipse, I was given the opportunity to do a short interview for NASA TV, and I was able to talk about my experience on live TV. I would like to thank The INSPIRE Project for this wonderful opportunity. I will keep my glasses close for the next solar eclipse in 2024.

Total Solar Eclipse with NASA – Nile Brown (12th Grade)

Nile with APSU's Dr. Rod Mills assisting with spray painting numbers on cows to track their behavior during the eclipse

The day I received an email from The INSPIRE Project asking whether or not I wanted to participate in NASA research for the Total Solar Eclipse in Tennessee was exciting. I knew this would be a once in a lifetime opportunity. As I thought more and more about this trip, I began to wonder what I would be learning. As the days went by and we finally reached the day of departure another question came to mind: What's so special about August 21, 2017? This would be the first continental eclipse in 38 years. The last one occurred February 26, 1979. I got to witness the Moon sit directly between the Sun and Earth and cast a shadow on our planet. Traveling to Tennessee put us in the path of greatness. I was able to see a total solar eclipse! Furthermore, not only did we have the opportunity to become a part of a historical event, we were placed into groups to conduct scientific research. As the eclipse progressed we were given group tasks to observe and record the actions of animals or to make balloon cameras that would track data about the eclipse. The eclipse lasted about 2 minutes. As the area around me got totally dark everyone got excited. In the back of our minds we hoped that we wouldn't by chance go blind even though during the eclipse you could only have your glasses off for a certain stage. The Eclipse impacted my life. It showed me a different phase of how science works in our relation to our planets and other scientific instruments used to investigate. After everything was over and the eclipse had ended, we celebrated with a victory meal. As we departed the next day the adventure ended, as it had begun with a cancelled flight. God bless our airlines!

Bryce at APSU Dunn Center attending NASA astronaut Rhea Seddon's presentation

My Eclipse Experience – Bryce Stephens (9th Grade)

The 2017 Great American Eclipse is one of, if not the most amazing things I have ever had the pleasure to experience. The view was beautiful and serene, but also somewhat eerie. As the Sun was slowly covered by the Moon, you could begin to see everywhere around you start to become darker and darker as time went on. You felt the temperature go from a hot summer day, to a nice, warm night as the Moon continued to cover the Sun. You could hear the crickets, one by one, start to make their way out and start to chirp. The talking soon slowed down and turned into simple "Ooo"s and "Ahh"s, until totality hit, and everyone burst out of the silence to applaud the amazing display. Over the speakers, the NASA organizers constantly said the time left in the eclipse, and whatever time they said, it always seemed to go faster. After it was over, the 360-degree sunset smoothly turned into a sunrise, and the darkness and cool temperature began to subside as well. After the Moon had completely moved out of the path of the Sun, it returned to exactly how it was before the eclipse. It was like time had stopped and I wish I could go back and experience it all again, the amazing, beautiful, and peculiar sight of the moon blocking out the sun.

Total Solar Eclipse – Christian Jenkins (8th Grade)

My experience seeing the solar eclipse was ecstatic. I was pumped up the whole day, excited waiting for the total solar eclipse to take place. As the moon was moving in front of the sun, I could hear people shout "Wow!" "That's cool!" "Look at that!" The eclipse was taking place. As I took a look away from the sun I spotted the birds moving in the opposite direction of the sun. I saw the cattle huddle up together in the field eating grass in the pasture. I heard the chirping of crickets nearby. Then I felt the temperature drop, it got cold and I began to get chills. That's when I knew the total solar eclipse was about to happen. Then WHOOSH!! Darkness covered the sky and all you could see was a big crystal ring in the sky. The solar eclipse was estimated to last about 2 and a half minutes but, it felt like it lasted for about 5 minutes because we were all focusing on the sky. Then it quickly went away as the moon moved away from the sun. It was truly an amazing experience. I was glad I had the chance to see the eclipse because this was a moment I'll never forget.

Christian assisting with atmospheric balloon launch at the APSU farm prior to the eclipse

My Solar Eclipse Experience – Julian Thomas (9th Grade)
My trip to Clarksville, Tennessee, for the solar eclipse, was exciting although we had to overcome some obstacles getting there and returning back home. On August 18, I arrived at Reagan National Airport to meet the other eleven youth and chaperones I was going to travel with. We get in the line to check in and, after several minutes, were told that our flight was canceled due to storm conditions. The adults in the group started talking about a number of options to get us to Tennessee. All of the typical options such as other airlines, Amtrak or Greyhound was already canceled for the day or booked through the weekend. Finally, my mother was able to contact someone in the Washington DC area who owned a charter bus company who was willing to drive us to Tennessee. The bus arrived at Reagan National Airport at approximately 6pm and we arrived at the Austin Peay campus at seven o'clock the next morning.

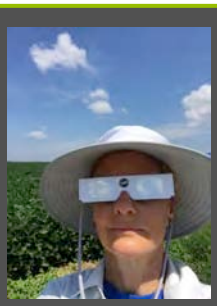
Julian with Mitzi Adams of Marshall Space Flight Center on the NASA-TV set at the APSU farm on Sunday prior to the eclipse

After arriving at the college, we had two hours to relax before going to breakfast and then the research farm. I slept during those two hours. I had a decent meal at breakfast and then it was off to the farm. It was a difficult transition to the farm because I wasn't used to the smell of the cow poop, and I was tired from staying up during the night on the bus ride. Most of the first day was spent in seminars getting information on the eclipse and going over the plans for the next couple of days. We also drove to another farm thirty miles away that evening where we set up an INSPIRE VLF radio receiver. Afterwards, we got back at the campus where I had the best sleep ever.

Day two was similar to day one pertaining to the planning at the farm. We basically went through more seminars in the hot Tennessee sun. However, what I found interesting was that we got to paint numbers on cows. The purpose of the cow painting was to chart their activity, and response to the solar eclipse. My cow was constantly moving and seemed afraid of me, but eventually she got through it. We were joined at the farm by the NASA Space Camp kids who came from Huntsville, Alabama. We all participated in more planning sessions where everyone got to ask questions. Afterwards, we left, ate dinner, relaxed and waited until the next day, the Eclipse Day.

On Eclipse Day, at the farm, we started off with our given assignments and went our separate ways. My assignment was to record the shadow bands during the eclipse. Because my experiments couldn't be done until a few minutes before the eclipse I decided to venture off to other projects. While exploring, I found myself in the company of a bunch of college students. They asked if I could help with making their weather balloon and I gladly accepted. So, I created two weather balloons which took up the majority of my time before my own experiment. The balloons were used to record temperature, brightness, atmospheric pressure and pictures of the eclipse. Two to three minutes prior to the eclipse, the temperature dropped, the wind speed increased, and there appeared to be a sunset of different shades of orange red and yellow. Birds went from flying in an arrow position to flying in a cluster. Dogs and wolves were howling as if it were the middle of the night, crickets chirped louder and the cows stopped grazing completely. I felt excited and scared because everything turned dark although it was still the middle of the day. People were taking photos. Most people were quiet, although some were shouting. During the eclipse the sky got darker and the temperature significantly dropped from 90 degrees to 60 degrees in a matter of 1 hour. Most people were quiet and trying to take the moment in. The eclipse created what appeared to be a full sunset. Additionally, the moon had a bright white hue. Lastly, the eclipse gave the sky a reddish orange color compared to a blue color for a brief period. Afterward, we had a debriefing session in the meeting area where we discussed what we observed. We then went back to the campus and freshened up before dinner. After dinner, we played in the field for a while before we all ran out of gas.

I went to sleep early that night anticipating the plane ride home the next morning, knowing that we had been a part of something special. It was an experience that I will remember for the rest of my life. Thank you to The INSPIRE Project, NASA Marshall Space Flight Center, and Austin Peay State University for making this possible.



ECLIPSE 2017 – Karin Edgett, INSPIRE Chaperone & Board Secretary

Two minutes and thirty-five seconds of absolute beauty treated my eyes and ears and mind and soul. Jeers came from watchers as they expressed their delight at this uncommon wonder. Silence from bugs and animals who are tuned in to something, be it darkness or a shift in temperature, or perhaps a recognition of a shift in energy. My eyes soaked up the diamondy shimmers along the edge of the moon, and followed the trails of the corona's wispy shapes. Knowing that millions of eyes turned upward, away from troubles, politics, negative thoughts, gave me some hope. Hundreds of scientists studied every detail they could think of. Did we learn anything collectively? Did we shift our idea of wonder? Or was it just me?

My Solar Eclipse Experience – Justice Flora (9th Grade)
The 2017 Solar Eclipse was a life changing experience. During my week at Austin Peay State University, the staff and INSPIRE leaders taught me many lessons about the Eclipse and how it effects the surrounding environment. However, along with learning about the Eclipse I believe that the experience was just as important if not more. When the Eclipse came into contact with my eyes it was something so breathtaking I was at a loss for words. By the time I took my glasses off the Eclipse was half way over. I was still taking as many pictures as I could before the Eclipse was over.

While at Austin Peay, Dr. Wright told us to use some of our senses. So, for the last 30 seconds of the Eclipse I used my senses to see if I noticed any changes. One of the first things I noticed was the drop in temperature because the moon was beginning to overlap the sun. The surrounding area became dark and there was a 360 degree sunset. By using those two senses, I was able to take in everything that was going on around me and understand what was happening. One thing that is still stuck in my head were the rays and corona produced by the sun around the moon. It was something I have never seen before. It looked as if a black ball was surrounded by one large diamond in front of the sun. I was thinking so hard about this my brain began to hurt because I couldn't believe what was happening.

Justice at the APSU dorm lounge with the INSPIRE team eclipse welcome cake

After the Eclipse I was thinking, what are the chances of this event happening and when will it happen again? I was so excited to find out that this event will happen again in 7 years in 2024. My Solar Eclipse experience is something I will never forget and will always be with me. I would highly encourage anyone to see the next Solar Eclipse in full totality if they have the opportunity. This event is something you may not want to miss.

Joshua on eclipse day at the APSU farm preparing for the atmospheric balloon launch

Eclipse Reflection – Joshua Simpson (12th Grade)
They said it was "a grand sight." He said it was "breathtaking." She said it was "spectacular." I said it was "a once in a lifetime opportunity." We all said something that afternoon, which made me realize how everyone experiences everything differently. Unlike most, I looked around at others' reactions to the eclipse. Some ran about in amazement, some mindlessly lost themselves in the awe of the black circle in the sky, and some were emotional. Nevertheless, no one shared the same response -- similar ones -- but none exactly like another. It really amazes me how unique we are even if we don't acknowledge it.

After that, I began to ask questions. I began to question people's experiences (ones that I shared with them). I would ask them questions such as: *Did you enjoy that event? What about the organization of the event could've made it better?* However, I didn't reserve these questions to the eclipse, but about everything.

The way individuals experience events relates to their personality. For example, if two people watch a butterfly cross their line of sight, one of them might see it as good luck, while the other could possibly have some irrational fear of the delicate creature and try to kill it. Then we could analyze these reactions and conclude that person 1 enjoys nature and its presence, and person 2 dislikes nature and its presence. Crazy right? I guess this is why they say actions speak louder than words, because just your reaction alone can determine so much about a person's personality. My experience can be described in just two words, "Just WOW!"

My Experience During the Eclipse – José Antonio Galicia Salazar
(National Polytechnic Institute, Mexico City, Geological Engineering Major)
I'm from Mexico City and a student at the National Polytechnic Institute. I participated last August 21 in the observation of the total solar eclipse at Austin Peay State University in Tennessee, as part of the research team of Mitzi Adams. I decided to help in the area of animal observation where the objective was to record the behavior of some cows during the whole process of the eclipse; however, we did not limit our analysis around us in looking for other effects of the eclipse.

At first it did not seem that the cows noticed what happened and didn't react even during totality. While the cattle did not react to the eclipse, other animals and insects did, we realized that nocturnal insects such as crickets and mosquitoes came out of the grass and acted as if it were at night, while bees returned to their hives and only went out to drink water.

Meanwhile in a pond, tadpoles appeared, rising to the surface to feed, and many birds were seen confused in their flight as they apparently didn't know how to react. We were fascinated by these sudden changes because minutes before everything seemed normal and unchanged. These strange phenomena didn't end there; at the moment when totality ended, I discovered something interesting; I noticed some watermelon flowers that were in the garden near where we observed the cows, were open before the eclipse, but after totality, they were closed. In my house I have crops of plants, watermelon relatives like cucumber and pumpkin, and from experience I know that their flowers only open in daytime and at night they close. I was intrigued for a moment until it occurred to me that these plants at the time of totality of the eclipse sensed that the day had finished and as a consequence closed their flowers. I shared these observations at the end of the eclipse with the professional researchers who organized the event, to which they mentioned that my finding turns out to be more important than I thought, because they did not think that there was a significant phenomenon in plants during that day and so they did not focus on plants. I was fascinated to be able to collaborate with NASA scientists, it was an experience of much learning, unrepeatable, that gave me important training right now that I am starting my professional career.

Two and a Half Minutes – Maysoon Harunani (11th Grade, Space Academy Student from Illinois)

11:57. There's a buzz of excitement in the air. People are dashing, trying to get their experiments set up. No one wants to miss a chance to be a part of something this grand. The progress to totality is said to have begun. There's a tiny speck on the sun. It's hardly noticeable to the eye with a pair of eclipse glasses, but noticeable nonetheless.
12:30. The temperature has begun to drop. The air feels significantly cooler. The moon continues to peak in front of the sun, but at least it is more prominent. People are getting anxious with the excitement building up. It's amazing to think of how much waiting there is for such a short period of time.
12:50. The sun finally starts to resemble the shape of the moon. To the naked eye, it appears to be exactly the same, throughout the entire time. Through the glasses, however, the expanding crescent of the moon on the sun is clearly visible.
1:18. There's a loud flutter. In an instant, every bird has left. They leave behind a silence, a silence filled by the sounds of cicadas and crickets, indicating the false dusk.
1:23. The surroundings attempt to imitate the night sky. The wind starts to pick up, blowing air that is significantly cooler. It is almost spooky, how the world falls under a gray spell.
1:25. There's a sunset all around. Off in the distance, a shadow is approaching. It's coming closer and closer, but still feels so far away. The time is ticking and people are consumed by jitters and eagerness. The countdown begins and people shout along with it, the volume increasing with each number. In a single motion, everyone removes their glasses to view the magnificent sight. Gasps of awe and wonder fill the atmosphere. There's an indescribable feeling in the air. Adrenaline races through the veins, leaving behind an elated state of shock. Seeing the sun covered by the moon – it is one for the record books. Cameras are clicking, people are posing. Everyone wants to capture this moment forever. The two and a half minutes come and go in a blur, signaling to the end of a truly euphoric event.

The Solar Eclipse – Sabrina Hare (12th Grade, Space Academy Student from Spain)

If I'm being honest, I was prepared for the eclipse to be a letdown. I was ready to discover that nerds and space enthusiasts had simply exaggerated what they saw. I imagined the eclipse would be the size of a golf ball, an insignificant circle which somehow thrilled scientists. I was wrong. Incredibly absolutely wrong. The solar eclipse far surpassed the expectations I had in mind. What first stunned me was the sunrise. Even though I had been told about the aurora effect, I was caught off guard by its beauty. As far as I could see in all directions, granted I had a lot of space since I was in a field, I saw only a sunrise. It was eerie. Imagine a sunrise, but instead of it in one direction, it's all around you. It was unlike any I had seen before, the colours seemed more varied. Plush pink, soft orange, a wave of glowing red infused with different shades of blue sky. While I gazed at the horizon, my skin tingled with the sudden rush of cool air. I recalled just hours before I had been drenched in sweat from the scalding sun. Amazingly, I felt like I had been transported from a blazing hot oven to a cool spring evening. While I watched, I suddenly noticed the sounds of crickets. Their nocturnal habits had prompted them to begin chirping during totality. After looking around, I decided it was time to finally see the eclipse. I craned my neck up and ignoring every bit of advice, looked directly at the sun. Except, there was no sun. Instead I found myself staring at a looming black hole illuminated by the bright white tendrils of the sun's corona. The corona flickered and danced on the outskirts of the moon. I finally understood why people had come so far just to see the eclipse. No image could ever capture the movement or beauty of the corona. No matter what I can say or show, there is nothing like truly witnessing a total solar eclipse. I can promise that even those people with a mild interest in space will be impressed. I encourage everyone to go out of their way to have the experience.

Sabina meeting Alabama Governor Kay Ivey at Elite Space Academy in Huntsville after returning from the eclipse

INSPIRE 2015 Space Academy Alumni Student Featured in *The Mars Generation*

Van Moreau

Greetings! Let me tell you a little bit about myself. My name is Cavan Moreau and I grew up in Sacramento, California. My mom moved to the United States from the island of Trinidad to attend college in her early twenties, pursuing a career in Physical Therapy. For as long as I can remember, I've strived to meet the parameters of Aristotle's quote: "We are what we repeatedly do, excellence then, is not an act, but a habit." This concept has helped define my future and the goals I reach for. During high school, I placed a focus on my academics, took AP courses, and I ran track, played football and wrestled. Today, I am fortunate to be attending the United States Military Academy at West Point. As a Cadet in the Army and a future officer, my days are spent working to pursue excellence in all facets of life. From studying for academic classes, to physical courses, military studies, and sports practice; a day as an Army cadet is a busy one - but well spent. I am currently studying Engineering Psychology and hope to commission into the Army as an attack pilot. In the meanwhile, I row for the Army West Point Crew team and I am a pilot in the Aviation Club.

Dreaming

Throughout my time in high school, I had a dream – several dreams – but I'll focus on the one that went out of this world. I always wanted to go to Space Academy, and eventually that became Advanced Space Academy. During my Junior year of high school I had already applied through Space Camp for the Space Academy scholarship two times, to no avail. I knew that Junior summer would be my last free summer, so during that year I decided to broaden my horizons and begin looking for more scholarships to apply for. Searching through the Internet one day, I stumbled on The INSPIRE Project and soon after submitted my application.

When I received an email from Ms. Kloostra one day stating that I had won a full scholarship, the joy was transcendental. Before I knew it I was stepping off of a plane in sunny Huntsville, Alabama. Throughout the week-long experience we engineered rockets that could safely transport an EGGstronaut, tested our confidence on the high ropes course, scuba dived to simulate zero gravity, ran a simulated mission to the moon, and most importantly, I got to work with a 5 star team of trainees. At the end of these exciting days the team headed back to the bays where we slept each night, but found ourselves spending our time becoming great friends with fellow teammates when we were probably supposed to be sleeping. On day 3 of space camp a film crew showed up and began to follow my team around. I thought this was cool, you know - probably pretty normal at the U.S. Space & Rocket Center. Until the next day when my team leader informed me that the crew's director wanted to talk to me – and so the journey began! I found myself recording short recaps after our projects and missions and a full-length interview at the end of the week.

After a couple of years, *The Mars Generation* made its debut on January 20, 2017 at Sundance Film Festival. I wasn't able to attend the festival due to my schedule, but I heard what my teammates thought of the movie and waited anxiously for its arrival on Netflix. With scientists such as Michio Kaku, astronaut Charles Bolden, and Neil deGrasse Tyson featured, there is a weight of credibility that makes this movie a must-watch for anyone with even the least of interest in space science. The movie explores difficulties we face in accomplishing space travel to Mars, while highlighting the trainees at Space Camp who may one day be the first to step foot on the red planet.

From my dream of attending space camp to ending up in a documentary, none of it would have been possible without the gracious scholarship of The INSPIRE Project. To them, I owe the utmost thanks and appreciation! I hope that you as readers, no matter where you are in life, will be INSPIRE'd to find a dream, define it, and pursue it. Because whether it be Mars or lifelong dreams, if you know where you want to go, you find out how to get there, and you never give up – dreams will become reality.

Van with his fellow Advanced Space Academy team members in 2015 at the U.S. Space & Rocket Center in Huntsville, Alabama

Kathleen Franzen Memorial Space Academy Scholarship Program

Space Academy – Inspiring Our Next Generation

During the past ten years, 32 educators and 59 students have been awarded full scholarships to participate in this weeklong, educational STEM program. Past recipients continue to be actively involved in the organization and serve as Ambassadors representing INSPIRE at workshops and events. Special thanks to INSPIRE's sponsors including the U.S. Space & Rocket Center, Washington Space Business Roundtable, District of Columbia Space Grant Consortium, Patriots Technology Training Center and private donors for their support and inspiring our next generation of scientists and space explorers.

INSPIRE's Kathleen Franzen Memorial Space Academy Scholarship Program is weeklong educational program for middle and high school educators and students held at U.S. Space & Rocket Center, NASA's official Visitor Information Center for Marshall Space Flight Center, in Huntsville, Alabama. Space Academy promotes science, technology, engineering and mathematics (STEM) through hands-on activities and missions based on teamwork, leadership and decision-making. The action-packed week includes 50+ hands-on STEM activities and experiments. Aside from astronaut training, the Space Academy for Educators program include intensive classroom, laboratory and training focusing on space science and exploration activities developed to promote learning in a classroom setting. The curriculum includes NASA content and is correlated to the National Science Education Standards. This hands-on program equips teachers with knowledge, activities and materials to excite, engage and attract students to STEM disciplines. After the 2016 Space Academy for Educators' graduation, INSPIRE partnered with NASA Marshall Space Flight Center to arrange a 4-hour interactive, hands-on presentation for the educators including a tour of four NASA labs at Marshall Space Flight Center. At the conclusion, teachers were given materials to take back to their classrooms. For the students, INSPIRE hosts an inter-active graduation lunch each year with scientists from NASA Marshall Space Flight Center.

In INSPIRE's annual 2016-17 school year survey, 100% of Space Academy for Educators STEM scholarship recipients (who are currently teaching) utilized materials and knowledge acquired via the weeklong Space Academy program directly impacting approximately 3,100 students in 32 Washington DC area schools. All new programs that were created as a direct result of the Space Academy for Educators program previously reported on continue to thrive including the first Space Club at DC's School Without Walls, Techbridge and hands-on rocketry at Kramer Middle School, and Deal Middle School's Robotics program which Dr. Alesia Slocumb started 6 years ago - Deal's team won the state competition last year and competed in the world competition in April 2016. Dr. Slocumb also arranged a field trip for the entire 8th grade of 500 students to go the movie "Hidden Figures" and followed up with classroom discussions about NASA and shuttle missions as well as reflection pieces about the movie to attract and engage students to STEM disciplines at her school.

2016 Space Academy Educators (left to right) Jucain Butler, Leah Young, Sasha Varner and Frank Matthews. Pictured below are the 2016 Space Academy for Students scholarship recipients.

2016 & 2017 Space Academy for Educators

Sasha Varner ~ Latin American Youth Center Career Academy

As a result her participation in 2016 Advanced Space Academy for Educators, mathematics teacher Sasha Varner of the Latin American Youth Center Career Academy added NASA's Pocket Solar System lessons to her curriculum. Her students also studied theories of black holes and completed scientific notation problems. In addition, she created a "Hidden Figures" lesson where her students studied NASA mathematician Katherine Johnson. Sasha was accepted into Towson's Graduate Computer Science program in December 2016 and is currently writing a book with Professor Otto Wilson from Catholic University of America on combining STEM education and gaming in the classroom to attract more students into STEM disciplines. Sasha's current STEM Coordinator was so impressed with her incorporation of space sciences and computer science in her curricula and her ability to engage her students in STEM programs this school year that upon her promotion to principal this month, she in turn promoted Sasha to the STEM Coordinator position for the 2017-18 school year.

2016 Space Academy for Educators recipients at NASA Marshall Space Flight Center. Pictured left to right: Andrea Tribo – USSRC Educator Programs Director, Jucain Butler, Sasha Varner, Frank Matthews, NASA/MSFC's Mitzi Adams who arranged the tour, Leah Young, and Barbara Cohen of the Moongrl lab

Jucain Butler ~ Patriots Technology Training Center

After attending 2016 Advanced Space Academy for Educators which included Robotics curricula, after school STEM coordinator Jucain Butler was inspired to volunteer and start an after school computer programming and robotics class at the Ridge Road Community Recreation Center in Washington DC to attract students in his local neighborhood to STEM disciplines at this traditional "sports" center. Ten students participated in this year's program. Some of the students from the Rec Center also participated in the First Lego League Robotics competition in the fall where there were three teams of ten students each in which he taught and coached. Jucain has also volunteered to serve as the Program Coordinator for the 8th Annual Solar Competition to be held at the Visitors Center at NASA Goddard Space Flight Center on April 25, 2018. This competition was developed by INSPIRE's late executive director Kathleen Franzen and past scholarship recipient Thurman Jones of the Patriots Technology Training Center.

Carlton Drew ~ STEM Coach

I was fortunate to participate in the International Educator Week in July 2017. I gained insights about how to encourage students to pursue opportunities in Science and Math. Thanks to my participation in INSPIRE's Educators Space Academy, I have shared resource materials and information regarding STEM certification program with Educators, developed a STEM partnership program for a PreK2-8 school, and adopted tools and techniques that I gained from meeting the Educators in the program for STEM competitions. I served as a Coach for the Lego First Robotics 2018 Hydrodynamics Challenge, Qualifier match at South River High School in Edgewater, Maryland in December 2017 – the project title was "Finding and Transporting Clean Water to Hurricane Maria victims." I am currently serving as a Coach for the Computer Criminal Investigator Team in the Patriots 2018 Cyber Security Competition and will be a judge in the RTCA Science Fair in March 2018. I've volunteered at several STEM Carnivals to encourage middle and high student to register for STEM competitions. The Space Academy program provided me with the long-term friendships, resources and tools as well as lessons learned for inspiring students to explore Science and Math.

(Above) Carlton Drew, Team Leader for the Winning 2017 Solar Competition Team at the U.S. Space & Rocket Center Space & Rocket Center in Huntsville, Alabama

(Left) INSPIRE 2016 educator and student scholarship recipients pictured in front of the Astrotrek Training Center at Space Academy in July

Jeamay Palo ~ Theodore Roosevelt High School
After joining Space Academy in July 2017, I became more inspired to motivate my students to pursuing careers in STEM. I continue to infuse my lessons with exciting topics about engineering and space exploration. In fact, we will be launching rockets in our football field this spring, as one of our projects in Algebra. I set up the first ever Robotics Club in our school, and am now coaching a team of 5-10 students. I have set up field trips to NASA centers in Washington DC and Virginia.

I had such an amazing time in Space Camp, that I was eager to have my students participate in it. So I coached 10 of my students who were interested in Space Camp, through their scholarship applications. One of them received a full-tuition scholarship from *The Mars Generation* and is going to Space Camp this summer! I am truly thankful to The INSPIRE Project for giving me this opportunity, and thereby opening doors for my students.

Space Academy for Students – 2017 *Journey to Mars* Solar Competition Winning Team

Space Academy 2017: A Space Odyssey – Kiera D.
If I had to choose a few words to describe Space Camp 2017, I would say that it was truly a Space Odyssey. Even though I didn't get to go to space, I stayed here on Earth and went to the U.S. Space and Rocket Center in Huntsville, Alabama. The trip was the First Place Prize that I won with two other teammates in the Patriots Technology Training Center's Solar System Competition. I met a lot of people, and I am happy to say that I made 7 friends during the week from across the country. A few trainees (camp participants) were from China and one trainee on our team was from Germany. There was so much to do at Space Camp! I participated in simulations, experiments and sessions on Rocket Science. During my first mission, I was the Flight Director in a Mission Control activity that simulated a shuttle mission to Mars. During my second mission, I was the Pilot as a member of the Shuttle Crew. I liked the Pilot role better because I got to control the Shuttle by devices on lots of panels and consoles. I went on the HyperShip, Moonwalk Simulator, and the 5 Degrees of Freedom Trainer, which are all parts of Astronaut training. We made 2 mini parachutes and assembled rockets that we got to launch! One the best moments I had at Space Camp was listening to the graduation speech, meeting, and taking a picture with the first Space Camp graduate to become an Astronaut – Dottie Metcalf-Lindenburger. Overall, Space Camp was a great experience! I would encourage you to go and experience it for yourself. It will be a lifelong memory that you will never forget. I would like to thank all the sponsors (Patriots, INSPIRE and the Washington Space Business Roundtable) for making this opportunity possible for me.

Kiera launching her rocket at the Homer Hickam Launch Pad

Ava V.
In June 2017, my brother and I won The Solar System competition hosted by The Patriots Technology Center and sponsored by the Washington Space Business Roundtable to go to Space Camp in Huntsville, Alabama. The Solar System competition taught me many great things. Space Camp is important because junior astronauts, like myself, need a place to practice what we are going to do in space. A few activities I enjoyed were space rocket trivia, rocket launching, rock climbing, visiting the IMAX Theater, and swimming in a man-made lake. Speaking of man-made, a simulator is a copy of something that is real. My favorite simulator was a mission where a mission specialist, commander, and pilot are in a rocket ship headed to Mars. The mission even simulated mission control which involved being in the mission control room, on earth, making sure everything went as planned. Each day I had to complete my first activity, attend a presentation, followed by the second and third activities, carry out a mission, attend another presentation, do the Space Shot, and concluded with a night activity. My favorite role was MMS1 also known as Mars Mission Specialist 1. This role was a task for one of the missions. I enjoyed it because I got to wear a real astronaut uniform and floated up a climbing wall on a chair. My favorite activity was launching a model rocket. It involved building a mini rocket from scratch and launching it. My rocket went the highest! After rocket launch, we rebuilt our rockets and

re-launched them. We shot the rockets rapidly and simultaneously as a team, so they looked like fireworks. One of my favorite memories was the Space Shot. The Space Shot simulated you launching into space. Looking back, my facial expression was hilarious yet I would do it again. My team spent a lot of time together and because of all the bonding, I made amazing friends from all over the country, including Cincinnati, Ohio and Louisiana. We even won the Outstanding Team award! I would love to return to Space Camp next year. It was a very special opportunity that I will never forget, especially because I went with my brother, Evan. Thank you!

2017 "Journey to Mars" Solar Competition Winning Team Kiera, Ava and Evan

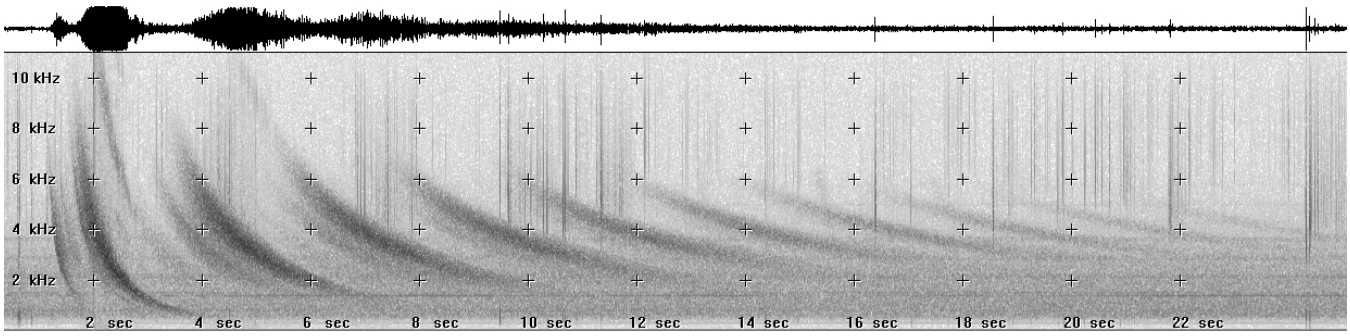
Evan V.

When I grow up I want to be an Engineer at NASA. I was privileged to attend Space Camp in August 2017 because I won a Solar System competition based on the theme "Journey to Mars" in our home state of Maryland. I was a bit nervous because it was my first time at Space Camp and I was concerned about making friends, but I made a friend on my first day! My favorite activities at Space Camp were the simulators like the 1A Chair and Space Shot because it felt like I was doing what the astronauts did in outer space. I also enjoyed, the Habitats because the beds were comfortable and I felt safe. I ate daily at the cafeteria and the meals were tasty and healthy. I was on Team Capricorn and our team worked so well together that we won the Outstanding Team award, on graduation day. My favorite memories were making friends from across the United States (like Michigan) and around the world (like China), who were as passionate about science and technology as I was. The missions were amazing. One role I played was MMS3 (Mars Mission Specialist 3) and in this role, I connected air vents to the Altair (which is the second stage of the Orion). Another role I enjoyed playing was Space Engineer, where I was tasked with making slime! Space Camp was an incredible opportunity for me and I would like to return next year to enjoy more fun science!

Yahoo VLF Discussion Group

Shawn Korgan, Founder & Group Moderator and Mark Karney, Group Administrator

The Yahoo VLF Discussion Group was founded by Shawn Korgan in 2001 for those interested in VLF (very low frequency) emissions. Over the past 16 years the group has grown to over 1,700 members. The Yahoo VLF Group is an open group and anyone can join and participate in discussions. Files and photos are not accessible until a person signs in with a Yahoo account; this is a Yahoo limitation which Mark and Shawn have no control over.



Amazing, very loud one-hop whistler with nine echoes! Don't expect whistlers to always be subtle in nature! (Image courtesy of Shawn Korgan)

Older posts contain many discussions regarding the types of sounds that can be received while newer posts touch on a numerous topics, many of which have to do with setting up home based VLF receivers. Mark and Shawn attempt to keep the group professional and on topic as much as possible which has led to its popularity and success. It is their mission for the group to continue to prosper in their endeavor to explore and understand the scientific world we live in.

Visit: https://groups.yahoo.com/neo/groups/VLF_Group/info **To subscribe, email:** VLF_Group-subscribe@yahoogroups.com

INSPIRE VLF-3b Receiver Technical Notes

Dr. Dennis Gallagher & Paul Schou
INSPIRE VLF Receiver Technical Advisors


Photo courtesy of
Tony Bateman, Finland

For 29 years, the INSPIRE VLF (Very Low Frequency) radio receiver kit has been designed with one underlying goal – to educate students of all ages about the sounds of space through hands-on experience. Building one's own electronic device is a step forward to opening the world of scientific exploration and showing that this complex world is made up of many simple components working together. *(Did you know the VLF-3b receiver kit has 114 parts?)* To date 3,500 INSPIRE radio receiver kits have provided students the opportunity to experience the sounds of space firsthand and the interest in VLF kits continues to increase. INSPIRE VLF receiver kits have been incorporated in pre-college and higher educational curriculums throughout the world. The receiver's features include an internal battery / external battery connection and stereo audio plugs for listening to the VLF signals between 300 Hz up to 20 kHz.

VLF Receiver Initial Diagnostics – Part II **Dennis Gallagher**

This is follow on initial diagnostics from The INSPIRE Journal (Vol. 22) when you have built the VLF3-b and it just doesn't work.

1. Do both of the LEDs light up with both power switches turned on? If not, then check to be sure D1 isn't reversed. Power on the external side of D1 should appear on the opposite side. Leave the 300 Hz high pass filter switched out. Leave the Mic input switch toggled to the data out2 side, not to the mic input.

2. Do you have an amplifier that accepts a microphone input such that you can connect to the receiver data output? In a pinch, you can use a line input connection with the input or record volume turned up. With just the receiver power turned on, can you raise the data level (clockwise) slowly and hear either a buzz from 60Hz or any audible hum?

3. If you hear nothing, not even hum, then the input to F1 or Q1 may be shorted to ground. Measure resistance for each to ground and to positive power; and if nothing is shorted, measure all along the signal path between the output of F1 and the input to Q1, on either side of C5 and L2. None should be shorted (zero resistance) to ground.

4. If one of these locations is shorted to ground, then look more closely for solder bridges near the incriminated location. Lacking that start removing components that connect this signal path to ground. A component could be bad, shorted, like C6 or C7, so remove the lead for either of these connected to L2 first in order to see if the short disappears. If that doesn't do it, start disconnecting resistor leads connected to the signal path. If after having removed all component leads (letting them dangle, still connected on the ground or power), the location in question is still shorted to ground, then there must be a PCB trace with a problem. Look again, even closer to what's left connected.

5. If there is no short along the path between F1 and Q1, look on the input side of F1 and output side of Q1 for a short and repeat the diagnostic technique to systematically isolate the spot with the short to ground (or power really) in order to identify what is causing the short.

6. If you do not find a short to ground along the signal path, then F1 or Q1 may be bad. If you have an oscilloscope, you can look at the signal at the gate for F1, and the drain for F1 to see if the signal is getting through this device. The same for Q1.

7. Another way to do this without an oscilloscope might be to turn on the receiver, turn the gain to some medium to low data gain setting and connect your finger to the output of Q1 and work your way back to the input of F1. You should hear a buzz that grows in amplitude as you work your way back to the antenna input.

8. If in step 3 you hear a buzz, then you need to take the same approach to look for a short or bad component that feeds the Audio output. In this case you are looking from pin 3 of IC2A along the signal path to pin 5 of IC1. The audio output can be monitored with 8 ohm headphones.

Share Your VLF Observations in The INSPIRE Journal

The INSPIRE team invites you to share your VLF observations with our readers. Describe your experience, including any comments that relate to carrying out your field observations. Field photographs and spectrograms are welcome components along with a short bio and photo to accompany your INSPIRE Journal submission. All submissions are reviewed prior to publication.

VLF Online Resources

YAHOO VLF DISCUSSION GROUP
(see page 46 of the Journal for more info)
https://groups.yahoo.com/neo/groups/VLF_Group/info

VLF GRAPH CONVERSION SOFTWARE
Spectrum Lab: http://www.qsl.net/dl4yhf/spectra1.html

VLFrxTools: http://abelian.org/vlfrx-tools

LOCAL TIME TO UTC CONVERSION
http://www.worldtimeserver.com/current_time_in_UTC.aspx

To Purchase an INSPIRE VLF-3b Kit & Download Assembly Instructions and Observation forms
http://theinspireproject.org/default.asp?contentID=3

INSPIRE Kit Questions, VLF Observation Journal Submissions:
CustomerService@TheINSPIREProject.org

TheINSPIREProject.org

INSPIRE VLF-3b Radio Receiver Kit Ordering Information

INSPIRE VLF-3b Radio Receiver Kits can be ordered online at:
www.TheINSPIREProject.org

INSPIRE accepts purchase orders for multiple kit orders. Discounts are available for non-profit organizations utilizing kits in middle and high school STEM curriculums.

For more information, contact CustomerService@TheINSPIREProject.org

Invest Today for the Exploration of Tomorrow

The INSPIRE Project's STEM educational programs provide scholarships and internships to educators, middle/high school students, and university students to ensure the next generation of space science and technology explorers. We currently do fundraising through grants and corporate partners. However, programs that are now offered have grown exponentially. In order to continue fulfilling our expanded mission, INSPIRE is seeking additional partners and sponsors who understand the importance of providing STEM educational opportunities to educators and students. INSPIRE's programs provide students the resources to pursue study in STEM disciplines. *Contributions are tax-deductible.*

Photo by Eva Kloostra, U.S. Space & Rocket Center ~ Huntsville, AL in August 2016

For more information on individual and corporate giving opportunities, please contact INSPIRE's Program Manager Eva Kloostra at Editor@TheINSPIREProject.org.

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