INSPIRE
INTERACTIVE NASA SPACE PHYSICS
IONOSPHERE RADIO EXPERIMENTS

The INSPIRE Journal

VOLUME 27 SUMMER 2024

A publication of The INSPIRE Project Inc.

Contents

Special thanks to the following for their contribution to The INSPIRE Journal:

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Mitzi Adams – NASA Marshall Space Flight Center
Eric Day – NASA DC Space Grant Program Manager
Dennis Gallagher – NASA Marshall Space Flight Center
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COVER IMAGE: Composite image of the sequence of Baily's beads during the 2024 total solar eclipse. The left side of the image begins just before the irregular limb of the Moon moves slowly to divide the brilliant light of the photosphere into points of light called Baily's beads. They disappear at 2nd contact (C2). After totality, at 3rd contact (C3), the opposite progression occurs. The motion of the Moon reveals early small beads that slowly coalesce into a large crescent of photosphere. The large triangular prominence at the 5 o'clock position was spectacularly revealed after 3rd contact. Observation site: Jackson, Missouri.
Image Credit: Gordon Telepun and Nicholas Telepun

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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.

IN MEMORIAM
Kathleen Franzen, President 2005 – 2010
Jack Reed, INSPIRE Board Member 1992 – 2009
Jim Ericson, INSPIRE 1st Vice President 1981 – 2006

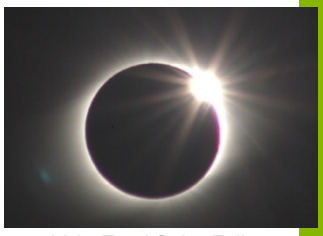
MISSION
The INSPIRE Project Inc. is a non-profit scientific, educational corporation whose objective is to bring the excitement of observing natural and manmade radio waves in the audio region to high school students. Underlying this objective is the conviction that science and technology are the underpinnings 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 2009, The INSPIRE Project expanded its STEM educational programs to provide scholarships and internships to educators, middle/high school students, and university students to ensure the next generation of space science and technology explorers.

From the Editor/Program Manager

Eva Kloostra



2017 Total Solar Eclipse
Clarksville, TN

Seven years ago, solar scientist Mitzi Adams of NASA Marshall Space Flight Center (MSFC) invited INSPIRE to join an amazing field research team for the August 2017 total solar eclipse – an event that had not been visible in the US since 1979. Twenty-two INSPIRE team members, including twelve Space Camp alumni middle and high school students, traveled to Austin Peay State University in Clarksville, Tennessee to conduct hands-on research before and during the eclipse. Our group was fortunate to have perfect weather for optimal viewing, awesome mentors, and life-long memories! The NASA/MSFC team received a NASA Group Achievement Honor Award for the program.

Seven years later, I am happy to report that all of the students have graduated from high school and are attending college (or have graduated from college!); and the majority chose a STEM discipline for his/her major. Personally, it brings me great joy when I get an email or text from one of the students telling me about his or her exciting endeavors. AND seven years later, there was a second total solar eclipse visible in the US – two in one decade! In this issue, Mitzi Adams reports on not only the April 2024 total solar eclipse, but also on the annular eclipse which occurred in October 2023, that was observed in Texas. Eclipse photographer Dr. Gordon Telepun shares his phenomenal photos from Missouri; and INSPIRE's Board Secretary reports on her eclipse experience in Erie, PA.

The solar eclipse also spiked interest in Very Low Frequency (VLF) radio both nationally and globally. INSPIRE's hands-on VLF-3 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 – over 4,000 kits have been distributed since 1989. Bill Detschel used the VLF receiver this year to teach his 9-year-old grandchildren about space science and discusses how the receiver can be used with grade school students to stimulate interest in space *(page 17)*. Peter Wright from Bangkok shares his insightful tips for building the INSPIRE VLF radio receiver and using it in the field *(page 38)*.

Since 2009, INSPIRE has offered educational STEM programs for middle/high school educators and students, and college/university students. To date, INSPIRE has awarded 171 STEM scholarships and internships, thanks to the generous support of program sponsors, friends, and the NASA DC Space Grant Consortium (DCSGC) – our affiliate partner. In this issue, recent INSPIRE scholarship and internship recipients share their experiences; and DCSGC Annual Student Research Competition participants discuss the exciting research projects being conducted at universities in Washington DC.

On behalf of the Board of Directors, thank you for your continued support of The INSPIRE Project's mission and STEM programs; and we hope you enjoy the 2024 *Journal*.

Never Stop Exploring – Eva

The following poem was written by Anna Baldwin after viewing the 2017 eclipse in Clarksville, TN. Anna was a 16-year-old student participant of the NASA/MSFC Eclipse Team. She submitted her poem to me this month and it brought back wonderful memories…

The beginning of an eclipse is uneventful.
Most people don't even notice when it starts,
but as the moon lazily makes its way in front of the sun,
colors start to look muted,
things get dimmer,
the air stands still.
The world is slowly going to sleep.
You feel it in your entire body,
this heavy awe blanketing the planet.
It's like the universe is reminding us how small we are,
how much power it has over us.
Closer to totality,
the crickets come out,
the cows start to graze,
this musky smell starts to appear.
You feel the need to be quiet.
Everything turns to a whisper,
as if the sound of your voice will somehow disturb the celestial dance taking place right above your head.
All the creatures of the earth hold their breath in anticipation.
Light slowly disappears, until finally,
the last bit of sunlight is obliterated by the moon,
and the ring appears -
this glorious halo of light,
circling a disk of darkness.
All around you,
the horizon has caught on fire,
the pale pink of the sunset fading into the dark blue of the eclipsed sky.
It only lasts a moment,
and then the world slowly goes back to normal.
The daylight comes back,
banishing the last few minutes into memory.

Since 2017, Anna graduated from high school, earned a degree in English from Central Washington University, and moved to Colorado where she enjoys camping, mountain climbing, and writing. Pictured above, Anna viewing the 2024 eclipse at a remote campsite in Colorado. "Now I climb mountains instead of building rockets, but I always get the feeling that I'm getting closer to the stars as I reach the summit."

Karin (orange cap) and her family, their winning diorama, and a heart-shaped phenomenon that showed up during the first phase of transit.

The Total Eclipse as a Family Experience

(Erie, Pennsylvania – 8 April 2024)

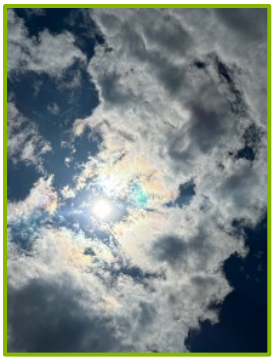
Karin Edgett, INSPIRE Board Secretary

For the past 30+ years, I have lived in Washington DC, where I became friends with INSPIRE's co-founder William Taylor and his wife, Kathleen Franzen. I currently serve as INSPIRE's Board Secretary. Over the years, I have had the pleasure of meeting so many bright students via our scholarship programs and through journeys to Space Camp in Huntsville, Alabama. In 2017, we traveled to Austin Peay State University in Clarksville, Tennessee to be part of the NASA Solar-Eclipse Team, which included INSPIRE Space Camp alumni students and educators, parents, other U.S. Space Camp alumni, NASA scientists, and other INSPIRE members. Our four-day research included field experiments in numerous locations using INSPIRE's VLF radio receiver to detect atmospheric noise, taking photos and 360º videos of the eclipse, and even noticing what the butterflies were up to. At that time, it seemed like the next total solar eclipse in the US to come in 2024 was a long way off.

Skip forward seven years, pandemics and other major changes, and the time was suddenly near. I am originally from Erie, Pennsylvania – a prime location for the 2024 total solar eclipse viewing. I happened to be there just before Easter visiting my mom at the senior residence, where she now resides, and they were holding a diorama contest using "Peeps" (a marshmallow confection shaped like chicks). My sister had the brilliant idea to make our diorama eclipse-themed, since Erie was in the path of totality and the city was super excited. We won first prize! My mom shared her own eclipse story that she referred to as "the end of times". When she was a little girl walking with her dad in the fields near their dairy barn in Busti, New York, suddenly all got very dark. She recalled that as the skies darkened, she and her dad walked back to the house where her mother and siblings were. She remembers her parents discussing what was happening and perhaps it was the *end of times.* An eerie sensation for sure. *(Probable partial solar eclipse on July 9, 1945)*

Karin's mom watching the 2024 eclipse.

I headed back to Erie in April for the 2024 total eclipse. My family pretty much all live in downtown on a bluff overlooking Port Erie Bay, a perfect viewing spot. A half a million people were supposed to be coming to the area for the event. On April 8, light rain and dark nimbus clouds blanketed the area, typical for Erie at this time of year. As the hour of the transit began you could see patches of blue sky were increasing and the clouds moving along quite rapidly. Only a few straggling cumulus clouds and high-flying cirrus clouds remained whose presence would add ambiance to enhance the experience. INSPIRE NASA Advisor Mitzi Adams sent us viewing glasses; and I brought tripods for my willing nieces and nephews to capture the event on various iPhone cameras. We cut several pairs of the NASA glasses apart and taped the solar films to our phones to be able to capture the transit more clearly. We also experimented between the iPhone default camera software and Moment camera software. The Moment software gave us a wider range of aperture and other settings, and in the end, we were able to capture some excellent details of the progress, of totality and of the diamond ring effect. About 20 of our family viewed the event - mothers and fathers, grandmothers and grandfathers, sisters and brothers, nieces, and nephews – ages 14 to 84. It was magic, all gathered around staring at the sky or taking photos. Then totality happened, all went cold and dark. Jackets were needed. The streetlights came on, the seagulls went crazy as they normally do at dawn or dusk, and the darkened skies created a dim sepia-toned atmosphere with a red glow on the horizon like the very end of a sunset. Random small cumulus clouds and the icy cirrus clouds lent to some more creative images.



The clouds parted as the moon approached the Sun.

Karin Edgett's Series of 2024 Eclipse Photos (Erie, Pennsylvania)

Beginning of eclipse using solar filter film from the NASA glasses and Moment software on an iPhone 14.

Reaching totality from the default camera app on the iPhone 14 Pro using the solar filter film from the NASA glasses.

Totality from the Moment software on an iPhone 14 Pro with the solar filter film from the NASA glasses.

Totality from an iPhone 11 Pro Max with no filter taken by Karin's nephew, Neil Edgett.

2023 NASA Intern and Howard University Graduate

Malaya Moon

At Howard University and as a NASA intern, I discovered the boundless opportunities within the STEM realm. Now, having graduated from Howard University, I look back on the past four years with pride for the accomplishments attained. During my fifth NASA internship at Headquarters this spring, I assumed the position of an Aeronautics STEM Engagement Intern, connecting with the younger generation – the future innovators of STEM. Within the NASA Office of STEM Engagement, I acquired practical experience crafting in-depth analyses of ongoing K-16 activities, employing both quantitative and qualitative approaches.

Moreover, an aspect of my internship that resonates deeply with me is the emphasis on youth engagement. Recognizing the significance of inspiring and nurturing the next generation of STEM enthusiasts, I actively participated in initiatives aimed at connecting with young minds eager to explore the wonders of science and engineering. This engagement with the youth not only allowed me to share my passion but also provided a platform for fostering curiosity, creativity, and innovation. It has been a journey of exploration, collaboration, and mentorship, where I not only expanded my knowledge but also played a role in kindling the flame of curiosity within the younger generation. This dual experience of personal growth and contributing to youth engagement has solidified my belief in the limitless potential of STEM and the importance of nurturing it for a brighter, innovation-driven future.

I express profound gratitude for being awarded the scholarship from The INSPIRE Project. As a first-generation college student, I deeply understand the significance of establishing a robust support system, both financially and academically. I am committed to pushing the boundaries of my own pursuits, aspiring to serve as an inspiration and carve out opportunities for the upcoming generation of trailblazers. My heartfelt thanks to INSPIRE for consistently bolstering my academic journey, and I eagerly anticipate stepping into the next chapter as I embark on my STEM career.

About Malaya Moon

Malaya Moon, a Howard University graduate with a B.S. in Computer Science, boasts an impressive array of achievements. She has been honored as a White House HBCU Scholar, Black Females Moving Forward (BFF) in Computing Scholar, and recipient of the Howard University Leadership Scholarship and Military Order of the Purple Heart Leadership Award. Malaya is also a distinguished member of the Upsilon Pi Epsilon International Honor Society for Computing and Information Disciplines. Her on campus involvement includes co-founding the Google Developer Student Club Howard University Chapter, participating in the Association of Computer Machinery, National Society of Black Engineers, National Society of Collegiate Scholars, Howard's Army ROTC program, and Howard's Georgia Club. Post-graduation, Malaya Moon has transitioned into a full-time role at MITRE, continuing to strive as a Cybersecurity Engineer.

NASA District of Columbia Space Grant Consortium Annual Student Research Competition

This annual competition is sponsored by the NASA District of Columbia Space Grant Consortium (DCSGC), one of 52 members of a national network known as "Space Grant," which encompasses more than 1,200 universities and organizations in every state, the District of Columbia, and Puerto Rico. The Space Grant Program is administered by NASA. The DCSGC offers DC university students opportunities for internships, fellowships, and scholarships, as well as research opportunities. It is all part of NASA's overarching mission to increase public knowledge, support educators, and attract and retain students to pursue STEM advanced degrees and careers. "For American University which serves as the lead institution of the Consortium in the District of Columbia, it provides opportunities to students to have authentic research experiences while supporting NASA missions in science and space technology," says Nathan Harshman, AU Professor of Physics and DCSGC Director. "One goal of the program is to broaden the pipeline of students prepared for joining the NASA workforce. The DCSGC also provides matching support to professional development activities to outreach and education projects and programs that build community and excitement around NASA missions."

Students present their research posters remotely by making videos and posting them on YouTube. Below are some of the exciting research projects at DC colleges and universities, presented at the 2023 (February) and 2024 (March) competitions. *Note: Published 2023 research competition submissions are from spring 2023.*

INSPIRE is an affiliate of the DCSGC which helps to fund many of its educational STEM programs.

CONGRATULATIONS TO ALL STUDENT COMPETITION WINNERS

2023

1st Place: Martha Rondon, Trinity Washington University
2nd Place: Lia Dolive, American University
3rd Place: Leah Chen, Georgetown University

Honorable Mention:
Rosa Lopez, Trinity Washington University
Stephanie Matamoros, Trinity Washington University
Cecilia Rivas, Trinity Washington University

2024

1st Place: Michael Bellacicco, Catholic University
2nd Place: Ben Wenig, American University
3rd Place: Alexandra Kauffman, American University

Honorable Mention:
Yuri Chung, Georgetown University*
Cecilia Rivas, Trinity Washington University*

** Not submitted for inclusion in The INSPIRE Journal*

2024 FIRST PLACE: Lateral Piezoresistive Behavior of CNT Yarn Under Compression

Michael Bellacicco, The Catholic University of America

I am a rising senior in mechanical engineering with a concentration in Aerospace Engineering at The Catholic University of America. Last year, I approached my academic advisor, Dr. Jandro Abot, regarding research roles on campus that I could partake in. He invited me to work in his Intelligent Materials Laboratory, in which we study piezoresistive carbon nanotube fiber (CNT) sensors and their responses to tension, compression, pressure, dynamic loading, heat, etc. I became part of the team, and I have participated in the fabrication of samples with integrated CNT fibers over the past few months.

The focus of my mentor's research (doctoral candidate Iriana Garcia Guerra) is the lateral piezoresistive behavior of CNT fiber. The goal of our laboratory is to develop CNT fiber sensors that could provide the strain, temperature or damage status inside materials. When looking at the results of our experimental program, it is promising. The gauge factor, or sensitivity, is twice the value of the response in the axial direction. More studies are being conducted to better understand this response and be able to predict the response under a variety of loading patterns. This includes dynamic loading for applications signal measurement in air and water.

To view Michael's presentation, visit: https://youtu.be/jKz5vXulJSY

Lateral piezoresistive behavior of CNT yarn under compression

I. Garcia Guerra, M. Bellacicco, J. L. Abot

Department of Mechanical Engineering, The Catholic University of America, Washington, DC, USA.

Introduction

- Carbon nanotube yarn (CNTY) is an extremely strong material fabricated from chemical vapor deposition and then spun to create a extremely thin and sensitive material.

Fig. 1. Spun CNTY on the spool

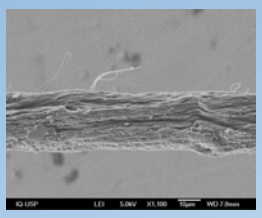


Fig. 2. Scanning Electron Microscopy (SEM) images of CNTY: 1100x

- Carbon nanotube yarn exhibits a piezoresistive response to strains, meaning there is a measurable change in resistivity when a mechanical strain is placed on the sample.
- Much research to date have focused on piezoresistive response in the axial direction, but the elastic modulus and lateral piezoresistivity in the lateral direction has not yet been studied.
- The goal of this research is to display how the electrical change in resistance of the CNTY mimics the change in strain, and therefore can detect strain in structures within aerospace, aeronautical, and civil engineering.

Methodology

- Four electrodes were used to connect the sample to the Date Acquisition software.
- This is more accurate than the usual two electrode measurement.
- A strain gauge was used to measure the strain experienced by the sample as the compressive force was placed onto it.

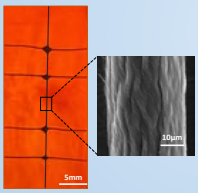


Fig. 3. Top view of sample with focus on CNTY

Manufacturing Process

The CNTY was placed inside of a epoxy resin sample in order to be tested.

1. First, points were measured in which the copper electrodes would be threaded through the silicon mold in order to ensure accuracy in measurement in manufacturing.
2. The four copper electrodes were threaded through the mold using a sewing needle at the initially measured points.
3. The CNTY was then carefully removed from the spool and securely laid lengthwise across the four electrodes.
4. Electric paint was then used to adhere the copper electrodes to the CNTY at the four points of connection.
5. The mold was then preheated in the oven at 130℃.
6. A preheated mixture of EPON™ 862 Resin and Epikure W (130℃) was poured into the mold.
7. The sample was then kept at 130℃ in the oven for one hour before a 24 hour cooling period.

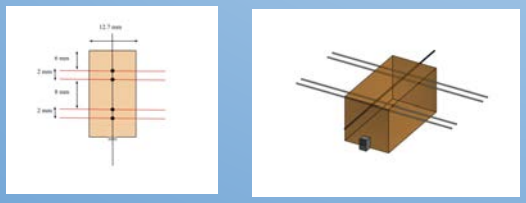


Fig. 4. Schematic of CNTY sample: (a) front view; (b) perspective view

8. After the cooling period a strain monitoring 120 Ω Omega ™ strain gauge was attached to the base of the side face of the sample.
9. After fabrication, the sample was able to be tested on a MTS machine.
10. The electrodes which measured resistivity and the strain gauge were both attached to Data Acquisition Software, where date was stored.
11. Ten cyclic loads were placed onto the sample in order to provide more accurate results.
12. The slope of the line allows the gauge factor, or how sensitive the fiber is, to be found.

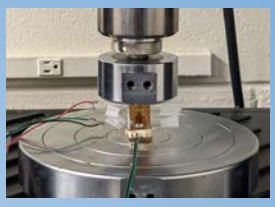


Fig 5. Experimental setup: sample zoom in the MTS

Results

- The 25 mm long 12.7 mm height sample subjected to 10 cycles of 1000 N load, at 1 mm/min show that the ratio of ΔR/R and ε follow the same pattern of response. (Fig.5-6)
- The maximum relative resistance change was about 0.038% and the maximum strain about 0.031% (Fig.6)
- This proves that the sensitivity of the CNTY acts in the same cyclic manner as the materials experience of strain.
- In Figure 7 the loading process is displayed, and the linear qualities of the graph allow for the gauge factor of the fibers to be found.
- The estimated gauge factor, which is calculated by the slope of the linearized loading part, is approximately 1.

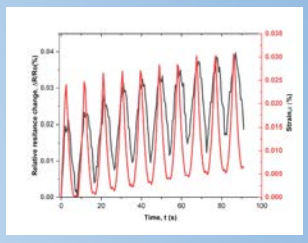


Fig. 6. Ten cycles 1000 N load, at 1 mm/min were run on the sample

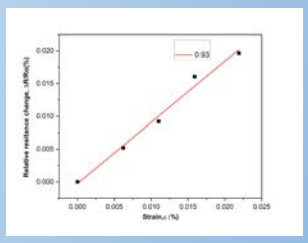


Fig. 7. The linear piezoresistive response of the loading part of the cycle.

Conclusions

- Garcia Guerra in recent study found that the gauge factor for axial compression was about 0.5, compared to that of the lateral compression which was about 1.
- This shows that the sensitivity in the lateral direction is nearly twice the amount as that of the axial direction.
- For future consideration look to changing the rate of the sample loading and hysteresis, or the unloading properties.

References

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- Garcia Guerra, I., Tayyarian, T., Rodríguez-Uicab, O., & Abot, J. L. Piezoresistive response of carbon nanotube Yarn Monofilament Composites under axial compression,(2023), *C*, *9*(4), 89. https://doi.org/10.3390/c9040089

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- NASA DCSGC and the Department of Mechanical Engineering at The Catholic University of America

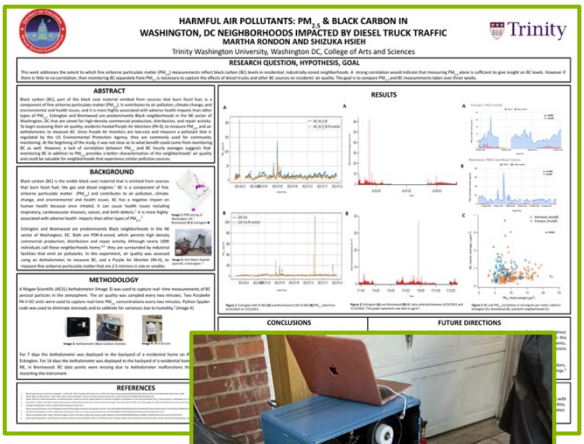
2023 FIRST PLACE: Harmful Air Pollutants: $PM_{2.5}$ & Black Carbon in Washington, DC Neighborhoods Impacted by Diesel Truck Traffic

Martha Rondon, Trinity Washington University

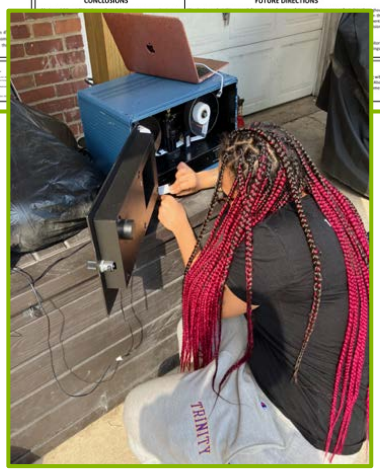
My interest in this research began during my junior year of undergraduate studies when I learned about the significant impact of environmental factors, notably air pollution like black carbon (BC), on genetic expression and health outcomes. I discovered that exposure to pollutants such as BC can exacerbate genetic risks, potentially leading to increased susceptibility to lung cancer and respiratory illnesses. Being from Washington, DC, I was acutely aware of the health disparities between economically disadvantaged and wealthier areas. This motivated me to explore how air quality might reflect these disparities.

During this research experience, I investigated air quality in industrially zoned neighborhoods of Washington, DC, particularly those with high Black populations. These areas were suspected to face significant air quality issues due to heavy diesel truck traffic emitting BC, a particulate matter known for its severe health impacts. BC is a visible soot that can deeply penetrate the respiratory tract, and long-term exposure is associated with an increased risk of lung cancer. Since BC is a component of fine particulate matter (PM2.5), which includes particles smaller than 2.5 micrometers, understanding its levels is crucial for assessing overall air quality. To address the lack of national regulation on BC, we partnered with local nonprofits and policymakers to use our data to advocate for equitable air quality policies.

Dr. Shizuka Hsieh introduced me to a project assessing air quality in Eckington and Brentwood – neighborhoods impacted by high-density industrial activity. Utilizing my cancer research and chemistry background, we employed a Magee Scientific (AE31) Aethalometer to measure BC and low-cost PurpleAir PA-II monitors for PM2.5 concentrations. We aimed to determine whether simultaneous monitoring of BC and PM2.5 would be correlated and thus provide a more comprehensive view of air pollution in these neighborhoods.


HARMFUL AIR POLLUTANTS: $PM_{2.5}$ & BLACK CARBON IN WASHINGTON, DC NEIGHBORHOODS IMPACTED BY DIESEL TRUCK TRAFFIC
MARTHA RONDON AND SHIZUKA HSIEH
Trinity Washington University, Washington DC, College of Arts and Sciences
Trinity
RESEARCH QUESTION, HYPOTHESIS, GOAL
ABSTRACT
RESULTS
BACKGROUND
METHODOLOGY
CONCLUSIONS
FUTURE DIRECTIONS
REFERENCES

In this research, I took on multiple roles, including contacting volunteers to host PM2.5 and BC monitors, deploying and maintaining these devices, processing data with Python Spyder, and organizing community meetings to raise awareness and seek solutions. The opportunity to present our findings at the Annual Biomedical Research Conference for Minoritized Scientists (ABRCMS) and the Society of Toxicology (SOT) provided a valuable platform for sharing our work. This experience emphasized the importance of building community connections, a crucial aspect of addressing health disparities in underrepresented communities.



Martha calibrating the Aethalmeter to ensure accurate BC monitoring.

Our findings indicated no significant correlation between BC and PM2.5 levels, suggesting that measuring both pollutants provide a more nuanced understanding of air quality. This underscores the need for dual monitoring to fully grasp the pollution landscape, particularly in areas affected by sources of black carbon, like diesel truck traffic. Long term, this research aims to illuminate the environmental factors contributing to health disparities by linking air quality data with potential health impacts.

Future research will involve extending the study duration to gather more statistically relevant data in multiple neighborhoods and deploying dedicated BC monitors (MetOne C-12). Additionally, deploying multiple PA-II units will enhance calibration and reduce measurement biases. These improvements will provide a more accurate and comprehensive dataset, aiding policymakers in making informed decisions about air quality management.

Thanks to the DC Space Grant Consortium for funding this work. I'm grateful to Dr. Shizuka Hsieh for introducing me to the project and connecting me with critical contributors like Dr. Valentina Aquila from American University, who assisted with Python coding, and Dr. Russ Dickerson at University of Maryland, College Park, who donated the aethalometer. Special thanks to the residents of Eckington and Brentwood for their crucial cooperation in highlighting local air quality issues, which underscores the collaborative nature of our research.

To view Martha's Presentation, visit: https://www.youtube.com/watch?v=ROYSASJ__fk

2024 SECOND PLACE: Using Machine Learning to Support the Future of Battery Technology in Space

Ben Wenig, American University

Ever since I was a young child, I have been fascinated by electricity and batteries. Having recently found my passion for analytical electrochemistry here at American University (AU) through working in the laboratories of Dr. Matt Hartings and Dr. Shouzhong Zou, I was graciously allowed to delve into the realm of machine learning thanks to the AU Physics Department. Through support from the DC NASA Space Grant, I was able to begin this research under the direction of Dr. Babak Salehi Kasmaei. Our end goal for this project is to create a reliable model to predict the behavior of batteries used in both terrestrial and space technologies. The first part of this project involved developing a machine learning model to accurately predict the lifespan of lithium-ion batteries under varied conditions, like charge rate, temperature, and so on. We used a benchmark data repository from the NASA Ames Prognostics Center of Excellence (PCOE), which contains a plethora of datasets on battery lifespans. One of the main ML algorithms we utilized was the multi-layer perceptron (MLP) neural network which is a mathematical model inspired by a network of neurons in the human brain. This multi-layer perceptron has weights and biases on its links, and the training algorithm iteratively finds the appropriate values of weights that give the best fit to the training data. Our results are quite promising and applicable to the physics of battery behavior in space. I am now actively working to develop a physical chemistry-based computational model to predict the behavior of the components of the batteries – such as the organic solvent and electrolyte salts – to ensure optimized conditions for batteries in other atmospheric conditions. By combining these two models, we envision a facile approach to the fabrication of new battery technologies and adapting these beyond our planet earth. I could not have done this work without the expert mentorship of Dr. Babak Salehi Kasmaei as well as my close friends, colleagues, and family.

To view Ben Wenig's presentation, visit: https://youtu.be/ss5bx8x3xEk

An Adaptive Method Based on Machine Learning for the State-of-Charge and State-of-Health Estimation of Lithium-Ion Batteries

Ben Wenig and Babak Kasmaei American University, Washington, DC

PROJECT OVERVIEW

Learn the electrochemistry of lithium-ion batteries

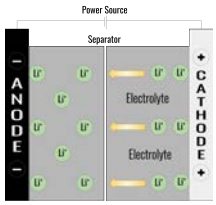
Study machine learning techniques in Python and MATLAB

Develop preliminary linear regression models from NASA dataset

Train an adaptive ML-based algorithm to the NASA dataset

Test the proposed model

LITHIUM-ION BATTERY CHEMISTRY AND TERMINOLOGY

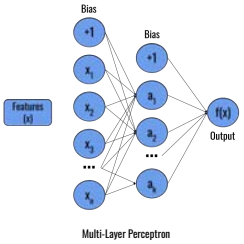


State of Charge: the level of charge of a battery relative to its capacity $SOC = \frac{C_{curr}}{C_{full}} \times 100\%$

State of Health: a comparison of a battery's current condition to its ideal condition $SOH = \frac{C_{full}}{C_{nom}} \times 100\%$

Common lithium ion battery electrolytes are lithium salts in an organic solvent, for example, lithium hexafluorophosphate in ethylene carbonate

MLP and SVR Regressor



Multi-Layer Perceptron

Given training vectors $x_i \in \mathbb{R}^p, i = 1, ..., n$, and a vector $y \in \mathbb{R}^n \epsilon$

SVR solves the following dual problem:

$$\min_{\alpha,\alpha^*} \frac{1}{2}(\alpha - \alpha^*)^T Q(\alpha - \alpha^*) + \varepsilon e^T(\alpha + \alpha^*) - y^T(\alpha - \alpha^*)$$

subject to $e^T(\alpha - \alpha^*) = 0$ and $0 \leq \alpha_i, \alpha_i^* \leq C, i = 1, ..., n$

where e is the vector of all ones, Q is an n by n positive semidefinite matrix, $Q_{ij} \equiv K(x_i, x_j) = \phi(x_i)^T \phi(x_j)$ is the kernel.

Here, training vectors are implicitly mapped into a higher (maybe infinite) dimensional space by the function ϕ.

The prediction is $\sum_{i \in SV}(\alpha_i - \alpha_i^*)K(x_i, x) + b$

NASA BATTERY DATASET AND DEFINITIONS

EOD (end-of-discharge): the duration of constant current discharge of a battery from a fully charged state to defined cut-off voltage

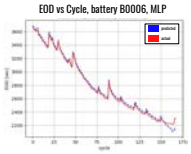
MLP (multi-layer-perceptron): a neural network algorithm that learns relationships between both linear and non-linear data

SVM (support vector machine): a supervised learning method used for data classification and regression

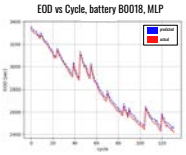
This project utilized the the Li-ion Battery Aging Datasets, posted on the NASA Open Data Portal, which contains thousands of discharge conditions from a custom built battery prognostics testbed at the NASA Ames Prognostics Center of Excellence (PCoE). The batteries were run through 3 different operational profiles (charge, discharge and Electrochemical Impedance Spectroscopy) at different temperatures.

RESULTS

EOD vs Cycle, battery B0006, MLP



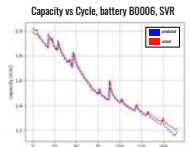
EOD vs Cycle, battery B0018, MLP



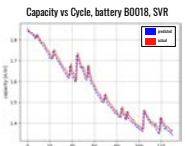
MLP Parameters:

activation= rectified linear unit function, L2 regularization: 0.001, batch size= auto, exponential rate decay: 0.9 and 0.999, early stopping= false, numerical stability: 1×10^{-8}, number of neurons in the hidden layer: 50, learning rate= constant, initial learning rate step size: 0.001, maximum function calls: 15000, maximum iterations: 10000, momentum for gradient descent update: 0.9, maximum number of epochs: 10, Nesterov's momentum= true, exponent for inverse scaling learning rate: 0.5, random number generation state: 1, shuffle: true, solver for weight optimization: adam, tolerance for optimization: 0.0001, validation fraction: 0.1, verbose= false, warm start= false

Capacity vs Cycle, battery B0006, SVR



Capacity vs Cycle, battery B0018, SVR



SVR Parameters:

regularization parameter: 1, cache size: 200, independent term in kernel function: 0.0, degree of the polynomial kernel function: 3, gamma: scale, kernel type: radial bias function, iteration limits: none, shrinking heuristic: enabled, stopping tolerance: 0.001, verbose output: disabled

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We would like to thank the District of Columbia NASA Space Grant Consortium and the American University Department of Physics for funding this research.

2023 SECOND PLACE: Iron Handling in the Tumor Microenvironment

Lia Dolive, American University

Last spring, as a sophomore at American University, I accepted a grant from the NASA DC Space Grant Consortium to work on my research project with Dr. Julia Chifman where we explore Iron Handling in the Tumor Microenvironment. As a mathematics major with an economics minor, research surrounding biology was unexpected and new and there was certainly a steep learning curve. However, throughout my time working with Dr. Chifman on this research, I have come to appreciate and enjoy working on biological topics, even if they are completely new to me.

Iron is a necessary nutrient required for many metabolic processes, including the transport of oxygen and cellular respiration. Iron aids in DNA synthesis, cell metabolism, growth, and energy production. The goal of an organism is to keep an internal equilibrium of iron within the body. However, the body can also have an excess amount of iron resulting in an inherited condition known as Haemochromatosis, or iron deficiency known as anemia that affects the production of red blood cells. In either case, deficiency, or excess of iron can be equally damaging and can contribute to a higher likelihood of various diseases, including cancer. The dysregulation of iron in relation to cancer at the intracellular level in a tumor microenvironment is the focus of our research.

Iron Handling in the Tumor Microenvironment

Lia Dolive and Julia Chifman

American University Department of Mathematics and Statistics

Abstract

The goal of this project is to build a computational model of iron metabolism at an intracellular level that concentrates on modeling iron trafficking among immune cells and cancer cells. Currently, the focus is on macrophages and, specifically, tumor-associated macrophages (TAMs). The polarization of macrophages dictates the Iron phenotype by determining the expression of iron-related proteins involved in the handling of iron.

Introduction

Iron is a necessary mineral for life. Iron is an essential nutrient, and it is needed for transporting oxygen throughout the body. Iron aids in DNA synthesis, cell metabolism, growth, and energy production. Conversely, the body can also have an excess amount of iron resulting in an inherited condition known as Haemochromatosis. In either case, the body is not properly regulating iron. The goal is to keep an internal equilibrium of iron within the body. Iron deficiency is the most common nutritional deficiency, and an excess amount of iron can be equally as damaging and can contribute to a higher likelihood of various diseases, including cancer. The dysregulation of iron in relation to cancer at the intracellular level in a tumor microenvironment is the focus of our research.

Many different cell types compose the tumor microenvironment, and it has been found that there are higher levels of iron in cancer cells than in other cells, each one of these cells either contributes to or inhibits tumor growth. Dysregulation is represented by reduced levels of iron exporter, associated with poor clinical outcomes, and high levels of imported iron – so when this dysregulation occurs, it can lead to more iron in tumor cells, which can result in a bad prognosis. A specific area we are concentrating on is Tumor-Associated Macrophages (TAMs) which, according to current literature, are present in solid tumors. Most agree there are two major types, pro-inflammatory (M1) and anti-inflammatory (M2) and it is possible for TAMs to be either type. The ratio of M1s to M2s decides if the prognosis is good or bad.

Materials

Petri Net Software

- Snoopy – Developed by the Computer Science Department at University of Technology in Cottbus, Germany.
- Snoopy is used to build and animate graphs such as Petri Nets

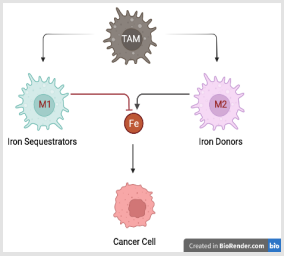
Methodology

Two Layers of Petri Net Models:

• First Layer
  - Intracellular Petri Net Models
    - Generic cells and Cancer Cells
    - Tumor-Associated Macrophages (TAMs)
      - Pro-inflammatory macrophages(M1)
      - Anti-inflammatory macrophages (M2)

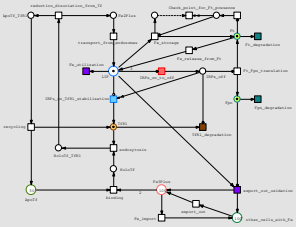
These macrophage models include iron uptake, storage, export, and utilization.

• Second Layer
  - Large-Scale Petri Net Model
    - Connects all cancer cells and macrophages
      - Allows for analysis of iron trafficking



Results

Petri Net model of the core iron for the generic cell



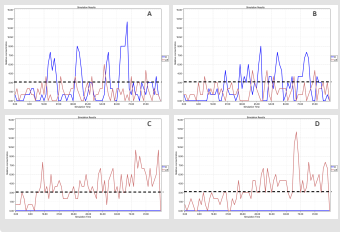
Simulation results

Figures A and B are two instances from our simulations that correspond to normal physiological conditions.

- Iron conditions: below 1 - iron is low, above 3 - iron is high.
- Iron storage (Ft) is represented by blue line.
- Available iron in the cell (LIP) is represented by brown line.

Under normal conditions, iron stays below a high level for the majority of the time. When iron levels reach 3 or higher, the regulatory effect of IRPs ceases, and iron storage (Ft) translation is no longer inhibited.

Figures C and D depict the effect of low iron storage (Ft) and iron export (Fpn – not shown) observed in many cancer cells. Iron levels are primarily elevated under these conditions, which is consistent with literature indicating that iron levels in cancer cells are also elevated.



Future Goals

- Expand iron utilization component.
- Build Petri net model for macrophages.
- Run comprehensive simulations for both cell types individually.
- Explore how over expression or knockout of specific species affects iron levels, to ensure consistency with biological observations.
- Build a dynamical system connecting cancer cells and macrophages.
- Explore if Anti-Inflammatory Macrophages can be reprogrammed by altering iron pathway? This is a controversial idea and will be explored using simulation.

Acknowledgements

- NASA DC Space Grant Consortium
- CAS Mathias Research Fellowship
- American University STEM Research Program

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Lia Dolive's poster on the research presented for the NASA DC Space Grant Consortium 2023 Student Research Competition.

Cancer cells have higher fitness, which results from their interactions with other cells and factors in their microenvironment. Immune cells in the microenvironment can either limit or promote cancer growth. It has been suggested that cancer cells and immune cells compete for iron and dysregulation of iron homeostasis in cancer is well documented. Dysregulation is represented by reduced levels of iron exporter, associated with poor clinical outcomes, and high levels of iron importer – so when this dysregulation occurs, it can lead to more iron in tumor cells, which can result in a bad prognosis. A specific area we are concentrating on is Tumor-Associated Macrophages (TAMs) which, according to current literature, are present in solid tumors. Most agree there are two major types, proinflammatory (M1) and anti-inflammatory (M2) and it is possible for TAMs to be either type. The ratio of M1s to M2s decides if the prognosis is good or bad. We present a preliminary mathematical model specific to cancer cells. We included major iron regulatory pathways and an external component corresponding to "other cells" that currently represents TAMs as a single node, which can both donate and retain iron. Our future goal is to expand "other cells" by including pathways and stimuli that are specific to classically and alternatively activated macrophages. The Petri Nets framework, which has been successfully applied to biological systems since the early 1990s, was used to design and analyze our model.

To view Lia Dolive's presentation, visit: https://youtu.be/6bOFxHRaD9M

2024 THIRD PLACE: Predicting Outcomes After Pediatric Cerebellar Tumors: The Impact of Lesion Location

Alexandra Kauffman, American University

Note: Because the participants of this study are from a vulnerable population and the results are preliminary, I am unable to provide graphics from this study.

This past May, I graduated from American University with a Bachelor of Science in Neuroscience. I worked in Dr. Catherine Stoodley's Cerebellum Cognition and Learning (CerCL) lab for the last three years investigating the role of the human cerebellum (the "little brain") in cognition and cognitive development. This past summer, I received funding from the NASA DC Space Grant Consortium and Mathias Summer Scholarship to continue my work on a project the lab is conducting in collaboration with Children's National Hospital. The aim of this project is to understand how lesion location within the cerebellum impacts developmental outcomes in pediatric brain tumor patients.

In recent years, the cerebellum has become an area of interest because 60% of pediatric brain tumors occur in the posterior fossa, which includes the cerebellum. Over half of these tumor patients have long term learning difficulties and other developmental challenges. Additionally, pediatric cerebellar tumor patients experience more long-term and severe deficits than adult patients, including a higher risk of autism and a lower IQ score. It is critical to examine both the region of the cerebellum impacted by the lesion but also the disrupted interconnected brain networks in order to understand these differences in development and behavior. We also know that the cerebellum has different subregions that support motor and cognitive behaviors, but these subregions are rarely incorporated into prognosis and long-term planning for patients. This project asked the question of how lesion location impacts outcomes, specifically within the domains of behavior and movement. We hypothesized that damage to motor subregions in the cerebellum will lead to motor deficits and behavioral dysregulation will result from damage to cerebellar subregions that support flexible behaviors. Our cohort included 32 patients with a history of cerebellar tumor resection. The most common tumor types were medulloblastomas and astrocytomas. The average age at surgery was 6.8 ± 4.2 years (1.2 – 16.2 years), average age at MRI scan was 12.7 ± 4.3 years (6.2 – 22.9 years), average age at neuropsychological assessment was 12.8 ± 4.3 years (6.2 – 22.2 years), and the average time between surgery and MRI / neuropsychological assessment was 5.9 ± 2.6 years (11 months – 12.5 years). This means that we are looking at long-term outcomes in these patients.

In order to evaluate the idiosyncratic lesions resulting from the removal of each tumor, we used each patient's structural MRI scans that were taken closest to the time of neuropsychological assessment. Because every brain is different, in order to perform group-level analysis of the data, each patient scan was warped into a standard template space using SPM12's Clinical Toolbox. Then, the lesions were delineated and mapped by hand in axial, sagittal, and coronal views in MRIcroGL to create a three-dimensional map of the lesions. We then related the lesion patterns to neuropsychological assessment scores measuring motor performance, cognitive performance, behavioral regulation, and adaptive function. To determine which lesion patterns were associated with below average (z score<-1) and above average (z score>1) performance, we created lesion overlay masks for patients falling into those categories for each task. This allowed us to test our hypotheses about the impact of lesions in specific cerebellar functional subregions on task performance. We also ran support vector regression lesion symptom mapping but because of our small sample size, there was not enough overlap at the voxel level to perform the analysis. Next steps include increasing our sample size, especially with tumors of the lateral

hemispheres, to examine whether cerebellar functional subregions predict outcomes using a voxel-level analysis. By considering cerebellar functional subregions, potential deficits can be better predicted and treated in children with cerebellar tumors, with the goal of improving long-term outcomes in these patients.

I am so thankful for the opportunities to present my research in the NASA DC Space Grant Consortium poster contest and the 34th Mathias Conference at American University. I continued working on this project for my honors capstone and cannot wait to see more developments from my lab after graduation. I want to thank the NASA DC Space Grant Consortium and Mathias Summer Scholarship for funding my research and the entire CerCL lab, especially Rebecca Tegiacchi, Alexandra Muir, and Brooks Baucom, for their help and support. Most importantly, I'd like to thank Dr. Catherine Stoodley for serving as such an incredible mentor these past three years.

2023 THIRD PLACE: Novel Hydrogen Peroxide Assay Technique for Characterization of Hydrogen Peroxide Responsive Nanoparticles

Leah Chen, Georgetown University

People often have strong associations between the medical field and the subjects of biology or chemistry. But as a physics major on the pre-med track, I sought to familiarize myself with the manifestations of physical principles in medical contexts. I found an ideal intersection of my two interests with the Georgetown Van Keuren lab during my second week on campus in Fall 2021, and I have been devoted to this research ever since.

Acute kidney injury is a sudden loss of kidney function. The overproduction of a reactive oxygen species (ROS) is a major contributor to the injury, especially as a side effect of recent cardiac surgery. For a patient, cardiac surgery associated-acute kidney injury (CSA-AKI) is a complication that extends hospital stays and prolongs recovery time.

My research involves a newly developed drug called APP-103 that aims to remedy CSA-AKI. APP-103 is a nanoparticle created by the high-shear mixing of a PVAX and dichloromethane solution with a PVA and water solution. The two immiscible liquids emulsify, resulting in a nanoparticle with a PVAX core encased within a PVA shell.

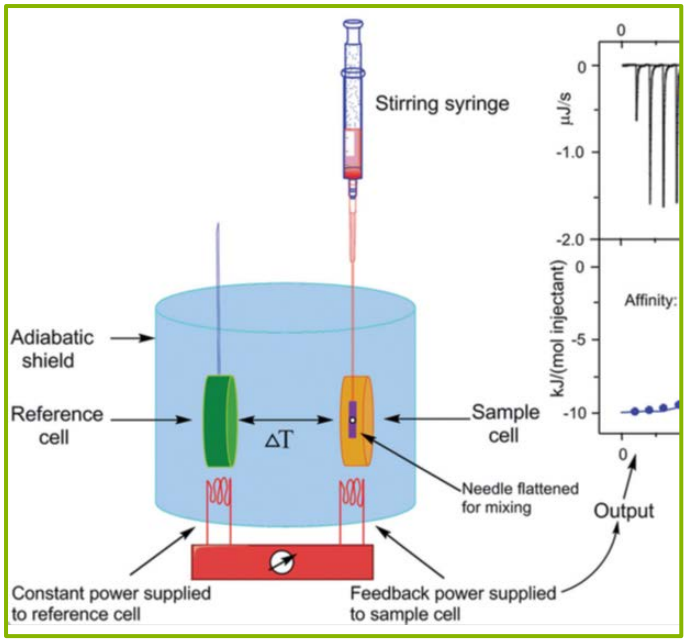
PVAX is the active ingredient in APP-103 as it reacts with the ROS, mitigating the excess. This reaction mechanism releases vanillyl alcohol as a byproduct, which possesses anti-inflammatory activity. The drug can alleviate CSA-AKI via two different pathways: as a site-specific treatment of ROS and through anti-inflammatory prevention of future kidney injury.

It is important to gain an in-depth look at how the APP-103 reacts with the ROS over time in order to predict how the drug will behave when administered to a patient. Our current technique of monitoring this reaction utilizes a UV-vis kit to detect leftover hydrogen peroxide (ROS) concentrations 24 hours after being in contact with APP-103. Not only is this process time consuming, but it only offers information about the final consumption of hydrogen peroxide, not reaction kinetics. It is novel and exciting—forward looking, ITC can replace assays in other contexts as well following the success of this application.

My research involves isothermal titration calorimetry (ITC), which can reveal the thermodynamics of a chemical reaction by measuring the heat that is released throughout 25 time increments. Though it is a technique commonly used in the field of biology, I have been unconventionally applying it to the field of physics. The ITC is able to titrate a small volume of APP-103 into a hydrogen peroxide solution during every time increment, during which it will track and record any heat that is released. This offers quantitative data on both the reaction rate and the consumption of the hydrogen peroxide itself. The aim of my research is to identify ideal concentrations and parameters such that the APP-103 reacts fully with the hydrogen peroxide, where the heat of reaction continues to decrease with time and reaches zero at the conclusion of the titration.

To run the experiment, I had to prepare solutions of APP-103 and hydrogen peroxide, both diluted with water. The samples were degassed to remove any air bubbles that had the potential to release heat during the titration. Then, I would load the APP-103 solution into the ITC syringe and the hydrogen peroxide solution into the sample cell. Time increment settings were adjusted, and the system was equilibrated before the titration could begin.

The research process was heavily trial and error. Altering the concentrations of APP-103 and hydrogen peroxide in their respective solutions vastly altered the heat of the reaction measured. Some results displayed a buildup of background heat, indicating the need for a longer time period between titrations or smaller concentrations. I considered external factors ranging



from the temperature of the lab to the pH of the solutions to the unavoidable background heat from the simpler water into hydrogen peroxide side reaction.

This experiment has yet to yield conclusive results. However, there has been a significant amount of progress in understanding the factors that can affect the success of ITC in a physical context. I am grasping a better understanding of the minute details that can drastically change the result of these experiments, which is reflected in the increased proximity of the results to the intended outcomes. In continuing to fine tune these parameters, my hope is that this research will eventually establish a more efficient, more accurate, and more quantifiable method for characterizing chemical reactions in the field of physics.

Figure 1: Diagram of Isothermal Titration Calorimeter

Source: Song, Chengcheng & Zhang, Shaocun & Huang, He. (2015). Choosing a suitable method for the identification of replication origins in microbial genomes. Frontiers in MICROBIOLOGY. 6.10.3389/fmicb.2015.01049.

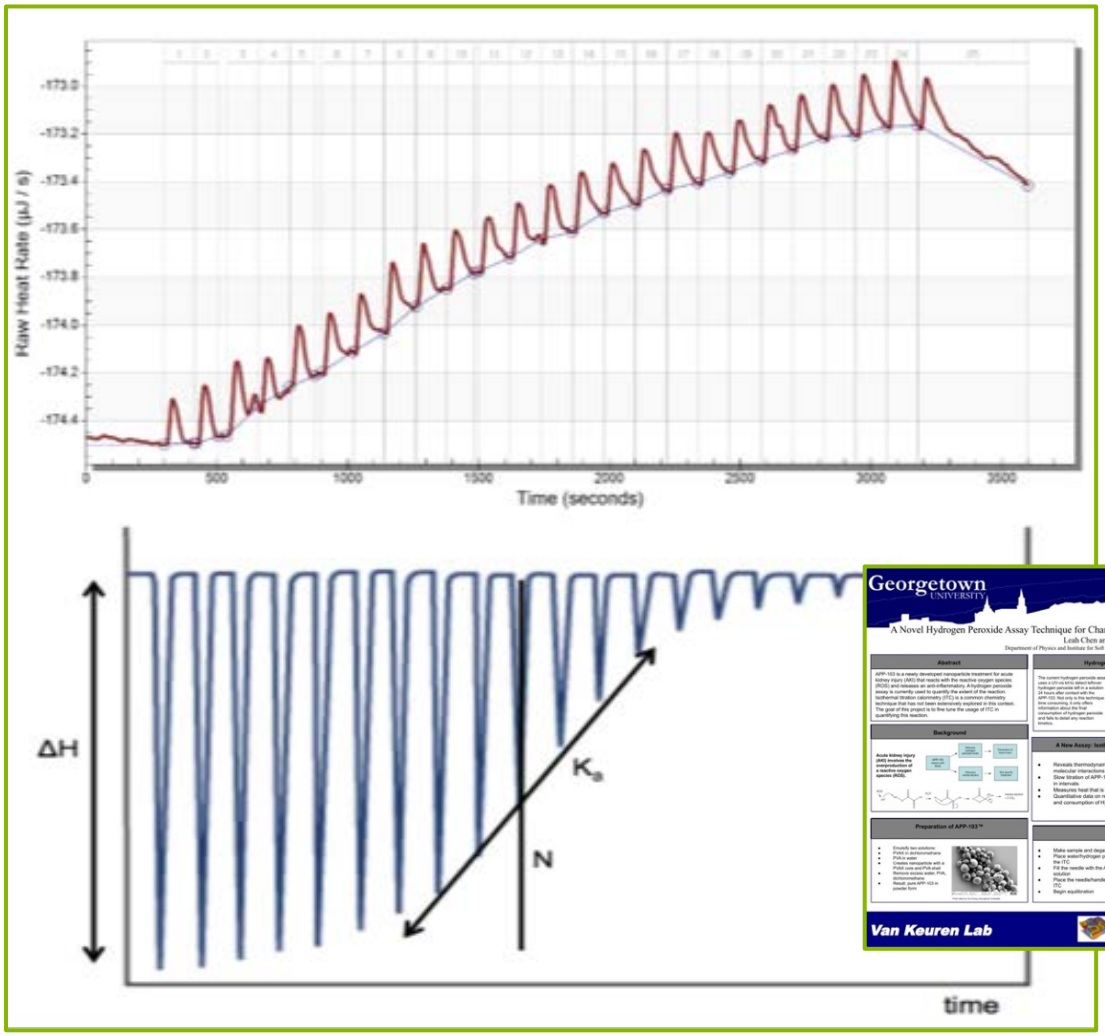


Figure 2: Isothermal Titration Calorimeter Data

Comparison of my data (top) and ideal data (bottom). The ideal data tapers off well, showing that the hydrogen peroxide is getting completely consumed by the end of the reaction. My data shows a build-up of background heat that could have many possible causes ranging from too short of time increments to too high of a concentration of APP-103.

To view Leah Chen's 2023 NASA DCSGC research presentation, visit: https://youtu.be/mATjzDqPkxA

2023 HONORABLE MENTION: Camera Trapping in Urban Areas: Open Versus Shaded Locations

Rosa Lopez, Trinity Washington University

I am a junior at Trinity Washington University majoring in biochemistry. In the summer of 2022, I had the privilege of conducting research at the university under the mentorship of Dr. Patrice Nielson. With the funding provided by NASA DC Space Grant Consortium and the incredible faculty at Trinity, Dr. Anette Casiano-Negroni, Dr. Shizuka Hsieh, Dr. Patrice Moss, and Ms. Georgina Nicholas, I was able to complete this research and present my work at ABRCMS. My research focused on camera trapping in urban areas like Washington DC. We first started by looking at previous research done on camera trapping to see what we could expect. We then set up our cameras in various spots around campus in open, grassy areas and in areas under the shade of trees and bushes. Our goal was to answer the research question, where in urban areas like Washington DC is wildlife most prominent? Contrary to our hypothesis, both mammals and birds were most often seen in open areas. This was a shock to us because we believed animals would have preferred areas that were shaded and away from all human presence. By comparing areas that were shaded versus areas that are open we were better able to understand how wildlife use heavily urbanized areas. This is important because local wildlife is getting pushed out of their habitats when nature is constantly disturbed, and man-made structures start to takeover.

I am grateful for this opportunity where I got to conduct research for the first time. And I got to not only learn about how to properly conduct research, but I also got to meet other scientists and learn about what they were investigating. Coming out of the COVID pandemic, this was my first real experiment and it was really meaningful and informative.

Thank you, NASA DC Space Grant Consortium, for the opportunity, Dr. Nielson for being my mentor, the faculty at Trinity for the team bonding activities and hours of practice on our posters, and finally to the ABRCMS 22 Dream Team – it was fun working with all of you.

To view Rosa's presentation, visit: https://youtu.be/1LjpzZQqjUo

Trinity

CAMERA TRAPPING IN URBAN AREAS: OPEN VS. SHADED LOCATIONS

Trinity Washington University, Washington DC
Rosa Lopez and Dr. Patrice Nielson
Trinity Washington University, Washington DC, Department of Biology

RESEARCH QUESTION, HYPOTHESIS, GOAL

Where in urban areas like Washington DC is wildlife most prominent? I hypothesize that in the summer, areas that are shaded will have more wildlife activity because their won't be as much human presence and the temperatures won't be as high. Our goal is to use camera trapping to measure the activity of wildlife on campus and compare if more wildlife can be seen in open or shaded locations.

BACKGROUND

Camera trapping is the process of setting up motion-activated cameras in places with wildlife activity, triggering the camera to capture images of wildlife (Rovero et al.,2013). Camera trapping is a good way of keeping track of the types of animals in an area as it is less invasive in natural habitats and not harmful at all. It's important in our study to use this method to be able to keep track of wildlife in urban areas for further research in intro biology classes.

METHODOLOGY

First we set up the cameras, making sure the batteries, SD cards, time, and dates were correct. We then looked at potential locations that would minimize capturing any human activity. We set up 6 camera traps (3 in open areas, 3 in shaded areas) throughout the Trinity Washington University campus (see map below). For a month cameras were placed on various trees approximately 18 inches off the ground and left on 24 hours per day, only taking pictures when activated by motion nearby. We swapped out the SD for a new one and monitored cameras weekly. We organized data into an excel sheet based on camera type, date, time, and species present. Finally, we used a t-test calculator to test for statistical differences in animal activity in shaded vs. open areas (number of pictures captured, number of species, number of bird species, and number of mammal species).

Figure 1: Map of Trinity Washington university Campus. Yellow dots signifies camera type and yellow arrow shows the direction at which it is pointed. The red dots signify the number of species photographed at each camera.

RESULTS

Our results show both mammals and birds are significantly more likely to be seen in areas that are open and free of large amounts of plants rather than areas that are more shaded. Our cameras captured images of squirrels, raccoons, foxes, starlings, robins, and other bird species.

Figure 2: View of camera that has an open area

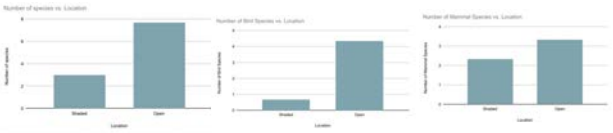
Figure 3: View of camera that has a shaded area

Figure 4: Total images of animal activity captured, p=0.0032, SE shaded areas=4.70, SE open areas = 5.36

Figure 5: Images of number of species captured, p=0.0178, SE shaded areas=1.00, SE open areas = 0.67

Figure 6: Images of number of bird species captured, p=0.0079, SE shaded areas=0.67, SE open areas = 0.33

Figure 7: Images of number of mammal species captured, p=0.3486, SE shaded areas=0.33, SE open areas = 0.88



CONCLUSIONS

We saw more species, mammal and birds in areas that are exposed rather than areas that are covered by various bushes and trees. This could be because wildlife may be more difficult to see in shaded areas and blocked by trees or branches, and the open area cameras had nothing but grass in view.

FUTURE DIRECTIONS

In the future we can advance our research by allowing students in biology labs to use the camera traps to try and investigate other research questions like if human activity interferes with the amount of wildlife in specific areas around the campus. This can be achieved by placing cameras in areas that get more populated throughout the day and comparing it to data of that same location when the campus is empty.

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ACKNOWLEDGEMENTS

I would like to thank my professor and mentor Dr. Patrice Nielson for her guidance in this project. Her excitedness and knowledge about wildlife in rural areas motivated me to complete this project as she guided me in designing and carrying out scientific research. Secondly I would like to thank professors Dr.Anette Casiano-Negroni and Dr. Shizuka Hsieh for their assistance on this poster and for their motivation. And lastly I would like to thank the NASA Space Grant Consortium for allowing this opportunity to take place through their funding.

2023 HONORABLE MENTION:
Carbon Nanotube Yarn Supercapacitor Integrated Sensing

Stephanie Matamoros, Trinity Washington University

As a chemistry student at Trinity, I never saw it coming, an internship in a Mechanical Engineering laboratory at The Catholic University. The experience was very different from what I was accustomed to in my chemistry and biology labs. I was excited to truly be engaged in an area of science that was foreign to me but yet intriguing. I learned about different materials and their properties. I learned about their applications and how materials adapt due to the various conditions or environments they are in. I was exposed to a culture where the laboratory was made up of postdocs and advanced graduate students. They really took me under their wings and were patient with me as I came up to speed. I truly treasured this experience.

My research mentors Dr. Jandro L. Abot and Abdulrahaman Binfaris first introduced me to carbon nanotube yarns (CNT) and their vast capabilities, such as its resistance to strain and temperature. They are lightweight and excellent conductors of electricity. Our research goal was to develop a supercapacitor that can incorporate CNT yarns as the primary conductor for energy. We conducted a literature analysis of different methods to build the supercapacitor while also studying the electrical properties of materials to identify the one that can provide high energy emission from the supercapacitor. The materials of the model primarily consisted of polydimethylsiloxane (PDMS), gel electrolytes such as poly vinyl alcohol and lithium chloride, and CNT yarn. In order to test the electrical current through the supercapacitor, a fast scan cyclic voltammetry device (FSCV) was used, which tests electrical currents and current densities. Ideal results would consist of high voltage and low current density. Our finding was similar to what other researchers have observed in their own experiments. Moving forward with this research would require enhancing the voltage current in future models.

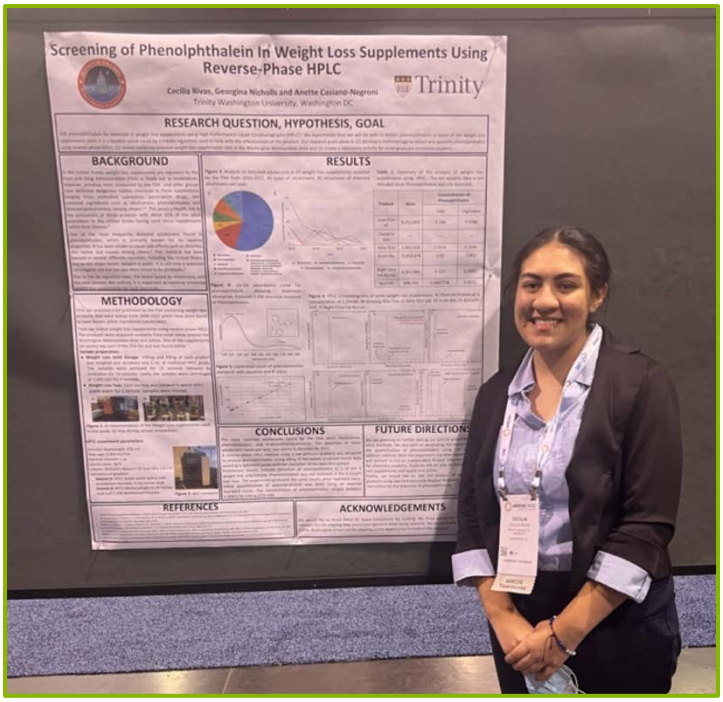
My research experience made me realize how focused one must be to truly accomplish a goal. I was humbled by the serious work ethics of the engineers I had the opportunity to work with and it has truly inspired me to never be okay with being average, but to always aim for excellence. I have a different perspective now as a rising junior here at Trinity and the expectations of my teachers and mentors. I am truly grateful to NASA DC Space Grant Consortium for the opportunity to participate in this life changing research experience. I am especially thankful to The Catholic University of America and my mentors Dr. Jandro L. Abot and Abdulrahman Binfaris for their guidance during my internship.

To view Stephanie's presentation, visit: https://youtu.be/EJ7_XcVjGBo

2023 HONORABLE MENTION:
Screening of Phenolphthalein in Weight Loss Supplements Using Reverse-Phase HPLC

Cecilia Rivas, Trinity Washington University

I am a sophomore majoring in Forensic Science at Trinity Washington University. During the Spring of 2022, when I was asked if I wanted to participate in research, I hesitated to say yes because I had only taken one science course, so I felt that I lacked the experience. Today, I am so glad that I did not let my insecurities and thoughts discourage me. During the summer, I conducted research at Trinity and participated in the NASA DC Space Grant Internship program. The mentoring and guidance of my mentors Dr. Anette Casiano-Negroni and Ms. Georgina Nicholls provided me, alleviated my anxieties about working in the laboratory. I gained experience working with scientific instruments and preparing sample solutions.



(right) Cecilia Rivas presenting her poster at the Annual Biomedical Research Conference for Minority Students (ABRCMS).

All of these have helped me in the science courses I am currently enrolled in. My research work focused on developing a methodology to detect and quantify phenolphthalein adulterants in weight loss supplements using reverse-phase high-performance liquid chromatography (HPLC). Phenolphthalein is a laxative that has many side effects such as nausea, and diarrhea, as well as carcinogenic and genotoxic risks. Our research goal was to create an independent project activity for undergraduate chemistry students where they would screen and quantify phenolphthalein in randomly selected weight loss supplements using HPLC. We began our research by analyzing a list of weight loss products published by the Food and Drug Administration (FDA) to determine which adulterants are most commonly present. The list included information from 2009-2022. We found that phenolphthalein is listed as one of the most common adulterants and among the 97 weight loss supplements listed, 14% contained phenolphthalein. We then randomly selected and tested 12 weight loss supplements from around the Washington Metropolitan Area and the internet that included 6 weight loss pills, and 6 weight loss teas. We developed a sample preparation and HPLC methods to screen for phenolphthalein. Our preliminary results show that 42% of these products contained phenolphthalein. Going forward, we intend to continue improving our quantification method and writing a procedure to implement this as an independent project activity for students in chemistry courses. This activity will also bring awareness about this adulterant and the issues surrounding these products.

Screening of Phenolphthalein In Weight Loss Supplements Using Reverse-Phase HPLC

Cecilia Rivas, Georgina Nicholls and Anette Casiano-Negroni
Trinity Washington University, Washington DC

RESEARCH QUESTION, HYPOTHESIS, GOAL

Will phenolphthalein be detected in weight loss supplements using High-Performance Liquid Chromatography (HPLC)? We hypothesize that we will be able to detect phenolphthalein in some of the weight loss supplements since it is a laxative which could be a hidden ingredient used to help with the effectiveness of the product. Our research goals were to (1) develop a methodology to detect and quantify phenolphthalein using reverse-phase HPLC, (2) screen randomly selected weight loss supplements sold in the Washington Metropolitan Area and (3) create a laboratory activity for undergraduate chemistry students.

BACKGROUND

In the United States, weight loss supplements are regulated by the Food and Drug Administration (FDA) as foods not as medications. However, previous tests conducted by the FDA and other groups have detected dangerous hidden chemicals in these supplements ranging from controlled substances, prescription drugs, and untested ingredients such as sibutramine, phenolphthalein and desmethylsibutramine, among others.[1-3] This poses a health risk to the consumers of these products with about 15% of the adult population in the United States having used these supplements within their lifetime.[4]

One of the most frequently detected adulterants found is phenolphthalein, which is primarily known for its laxative properties. It has been shown to cause side effects such as diarrhea, skin rashes and nausea among others.[5] This chemical has been banned in several different countries, including the United States, due to the major health dangers it poses. It is not only a potential carcinogenic risk but has also been found to be genotoxic.[6]

Due to the lax regulation laws, the threat posed by adulterants, and the ever present diet culture, it is important to continue screening weight loss supplements for such chemicals.

METHODOLOGY

First, we analyzed a list published by the FDA containing weight loss products that were tested from 2009-2022 which have been found to have hidden active ingredients (adulterants).

Then we tested weight loss supplements using reverse phase HPLC. The products were acquired randomly from retail stores around the Washington Metropolitan Area and online. One of the supplements we tested was part of the FDA list and was found online.

Sample preparation:

- **Weight Loss Solid Dosage:** 100mg and 50mg of each product was weighed and dissolved into 1 mL of methanol HPLC grade. The samples were vortexed for 15 seconds followed by sonication for 10 minutes. Lastly, the samples were centrifuged at 3,000 rpm for 5 minutes.
- **Weight Loss Teas:** Each tea bag was brewed in warm HPLC grade water for 1 minute. Samples were filtered.

Figure 1: A) Representation of the Weight Loss supplements used in this study. B) Teas during sample preparation.

HPLC experiment parameters:

Detector Wavelength: 230 nm
Flow rate: 0.300 mL/min
Injection Volume: 5 µL
Column oven: 30℃
Column: Shimadzu Nexcol C18 5µm 50 x 3.0 mm
Low pressure gradient:
Solvent A: HPLC Grade water with 5 mM Ammonium Formate, 0.1% Formic Acid
Solvent B: HPLC Methanol with 0.1% Formic Acid and 5 mM Ammonium Formate

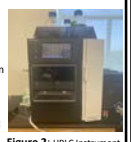


Figure 2: HPLC Instrument

RESULTS

Figure 3: Analysis of detected adulterants in 97 weight loss supplements reported by the FDA from 2016-2022. A) types of adulterants, B) recurrence of detected adulterants per year.

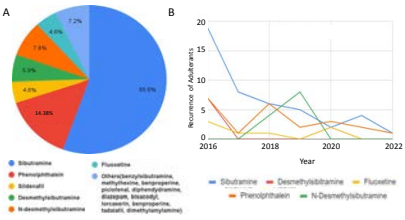


Table 1: Summary of the analysis of weight loss supplements using HPLC . The tea samples data is not included since Phenolphthalein was not detected.

Product	Area	Concentration of Phenolphthalein	
		mM	mg/tablet
Lean-Fire XT	6,251,033	0.196	0.9788
Zuccarin Diet	–	–	–
Keto Slim	1,065,423	0.0236	0.2030
Fruta Bio	75,858,678	2.52	2.802
Night time Fat-Burner	4,001,946	0.122	0.3905
Burn XT	378,730	0.0007278	0.0021

Figure 4: UV-Vis absorbance curve for phenolphthalein showing maximum absorption. Enclosed is the chemical structure of Phenolphthalein.

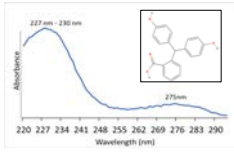


Figure 5: Calibration curve of phenolphthalein standards with equation and R^2 value.

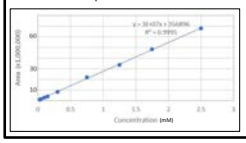
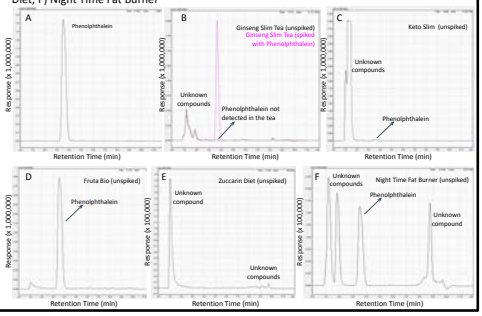


Figure 6: HPLC Chromatograms of some weight loss supplements. A) Phenolphthalein at a concentration of 1.25mM, B) Ginseng Slim Tea, C) Keto Slim pill, D) Fruta Bio, E) Zuccarin Diet, F) Night Time Fat Burner



CONCLUSIONS

The most common adulterants found by the FDA were sibutramine, phenolphthalein, and N-desmethylsibutramine. The detection of these adulterants varies per year, but seems to decrease by 2022.

A reverse-phase HPLC method using a low pressure gradient was designed to analyze phenolphthalein. Using 50mg of the tablets produced better data avoiding a saturated peaks with the exception of the Keto Slim sample.

Preliminary results indicate detection of phenolphthalein in 5 of the 6 weight loss pills/tablets. Phenolphthalein was not detected in the 6 weight loss teas. The experiment produced the same results when repeated twice. Initial quantification of phenolphthalein was done using an external standard curve. The concentration of phenolphthalein ranged between 0.0007278 mM to 2.52 mM.

FUTURE DIRECTIONS

We are planning on further testing our sample preparation and HPLC methods. We also plan on developing the experiment for the quantification of phenolphthalein using the standard addition method. Once the experiment has been developed, we will convert it into an Independent Project laboratory activity for chemistry students. Students will be able to choose weight loss supplements sold locally and online.

Finally, we would like to add the analysis of weight loss products using low-field benchtop Nuclear Magnetic Resonance instrument for the detection of phenolphthalein.

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I would like to thank the NASA DC Space Consortium for providing the funding for my research work and thus exposing me to excellent laboratory research experience, training, and mentoring. Also, I was fortunate to be able to present this research at the Annual Biomedical Research Conference for Minority Students (ABRCMS) and the Annual DC Space Grant Poster Competition. Thank you INSPIRE for allowing me to share my research experience!

To view Cecilia Rivas' 2023 presentation, visit: https://youtu.be/TPwV3VC18q0

Cecilia also participated in the 2024 NASA DC Space Grant Consortium Student Research Competition and received an Honorable Mention. To view her 2024 presentation, visit: https://youtu.be/iB_m-nH6uEw?si=NRfl4QHj7t_1wHMc

INSPIRE VLF-3 Receiver for Grade School Students

STEM Adventures with my Grandchildren

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Introduction

This article describes some “adventures” with my twin grandchildren Ashley and Nathan using INSPIRE’s VLF-3 Radio Receiver Kit. INSPIRE’s VLF receiver is directed in large part towards high school and university students, as well as adult researchers and experimenters, who build and use the receiver kit. My goal was to see what adventures can be had using the kit I built with grade school kids – e.g., my twin grandchildren Ashley and Nathan. Our adventures have taken place over the span of about 6 months, as they do not live nearby and we take opportunities when they visit to introduce them to various STEM subjects. I am a ham radio operator with electrical engineering background; their mom (my daughter) is a physicist and my son-in-law is an electrical engineer. So they definitely get exposed to a lot of technology! They are currently 9-years old, one boy and one girl. Fortunately they are very curious about the world and love learning. They build a lot of Crunchlab kits, in addition to the usual interests of sports and video games. They have always had an interest in space and keep up with NASA and SpaceX missions. As parents, my wife and I always tried to expose our children to different things in the world, learn about what they enjoy doing and what they are good at, and inspire them to follow that. So this project is aligned exactly with that approach for our grandchildren and INSPIRE is a great name for the project.

Goals

My overarching goal is to stimulate their interest in space, atmospheric phenomena, radio, and reinforce their general interest in science. As part of this, I want to help them understand a bit about natural radio, the layers of the atmosphere, how signals may be reflected around the globe, and how this is related to other phenomena. To accomplish this my plan was (is) to use this kit and information to help the twins understand how our atmosphere works to generate, reflect, and propagate natural radio signals and relate that to some of the other things they have learned over the years. As a concept, listening to Earth is pretty exciting in its own way, so this piqued their interest. Note that having technical background helps with using the INSPIRE receiver but it is not necessary in any way. Building the receiver kit does requires soldering and handyperson skills. The kit is well-designed and packaged; and the assembly and debug instructions are superb. If you can solder and screw things together, you should be fine assembling the kit. As for using the kit, examples are available on the INSPIRE website and documented in the *Journals* which are archived there.

Overview of Natural Radio and the INSPIRE VLF Receiver

Figure 1: INSPIRE VLF-3 Receiver Front Panel

The INSPIRE VLF Receiver allows students to explore the world of natural radio. As the name implies natural radio signals are radio frequency (RF) signals generated by the environment. Most natural radio signals are generated by lightning strikes, which generate broadband RF signals at VLF (very low frequencies), The signals can contain frequencies from 0 Hz to over 100 kHz. Hz is simply a term for vibrations per second and is known as the frequency. Our range of hearing is roughly 20 Hz to 20 20,000 Hz, also referred as 20 kHz. The range of a piano is about 25 Hz to 4,200 Hz, the vibrations we hear of course are acoustic (sound) waves. So the lowest note on a piano vibrates in air and creates a sound wave with frequency of about 25 vibrations per second or 25 Hz. Radio signals are electrical waves which are also vibrating at a specific frequency. They are generated in various ways, such as electronic circuits called oscillators, or as a result of electrical machinery (motors, fluorescent lights). They can also be generated by natural phenomena – lightning. Of course, we can’t “hear” them as we are not biologically equipped with radio receivers! But we can use radio receivers to pick up the electrical signals and turn them in to sound waves which we can hear. The radio detects the radio (RF) signal using an antenna feeding a detector circuit and the detector is tuned to a certain radio frequency (station). The signal then passes thru an RF amplifier, and is then converted it to an audio signal, this process is known as demodulation. The audio signal is amplified and sent to our speaker or headphones. (There is a bit more to it that that but that is the basic idea). A standard AM radio covers from about 500 kHz to 1550 kHz (also denoted as 1.55 MHz for Megahertz). The radio station encodes the music on to the RF signal and transmits it so a radio tuned to the proper frequency can pick it up. If you happen to listen to an AM radio during a thunderstorm – even if the thunderstorm is far off – you will hear some noise in addition to the music or voice. This might sound like pops and crackles. This is an example of natural radio!

The INSPIRE receiver comes as mentioned in kit form; its design has evolved over a few iterations. The current version is denoted VLF-3. You can see in Figure 1 the basics of the unit. It is powered be either internal 9V battery or external 9V supply

through a jack on the lower right of the panel. Everything needed for operation is accessible on the top panel. Across the top are the antenna connections. The antenna can be connected via a BNC jack or a terminal strip. Experimenting with various types of antennas yields some interesting results. But the basic antenna only needs to be about a 6-foot piece of wire or telescoping whip. The ground terminal should be connected to a ground stake or pipe for best results. Hands-on experimentation with antennas, was interesting for the kids. They got to see how various antennas resulted in a higher signal level or lower noise level. The antenna is not tuned in any way so the parameters are not critical. Probably the most important considerations are a good ground and keeping away from artificial sources of noise such as power lines, fluorescent (and some LED) lamps, and radio stations. In fact, the receiver is not tuned in any particular way as an AM or FM radio would be. Rather it receives the broadband signal in the atmosphere (E-field), filters it, and amplifies it.

There are two power switches, one for overall operation (Receiver Power) and one for Audio Power. There are also two level controls and two output jacks The information that comes from the RF signal is utilized through these in two ways:

1. Data – A low level filtered version of the RF signal which is run through the Data volume control to a stereo Data output jack. This output is for use with either a tape recorder for storage and later analysis, or as an input to a computer soundcard for use with spectrum analysis software. This software may be used to visualize the signal and was the more interesting for the kids.
2. Audio – This is the signal amplified to a level useful for driving headphones or a small speaker. It is routed through the volume control marked Audio to the stereo audio output jack. This can be used to listen for the atmospheric signals in the audio – spherics, tweaks, and whistlers are some of the signal types described. The Audio power switch must be on for this stage to work in addition to the Receiver power switch.

The reason for separate power switches is simple, it allows you to save battery power if you are not using the audio feature. There is a filter switch which may be used if there is significant interference from certain types of radio stations. Originally it was intended to filter out signals from a navigation system called Loran; this is no longer in service. It is also useful for filtering out loud signals from short wave radio stations. In general, we did not use this switch as it does decrease the sensitivity somewhat. But the kids did experiment with it. The final switch is the MIC/Data switch which we did not use; it is meant for recording a time signal (for instance WWV) or other audio info along with the data. The MIC audio will go to the left side of the Data output jack with the Data signal itself on the right side. In its down (off) position both channels get the data signal.

Figure 2: Basic Hardware Setup

Explaining VLF and INSPIRE to the Twins

As mentioned, my goal was to use the receiver and associated equipment to introduce the kids to atmospheric phenomena. INSPIRE is meant to be used in several ways. One may simply monitor the atmospheric activity with headphones. I could see using some audio filtering or signal processing in the chain to isolate particular signals. This would be an interesting area of future research. Being 9 years-old, the obvious choice for my grandchildren was to use the data output with some spectrum analysis software to allow them to visualize the signal. (Past experience working in the area of scientific visualization at IBM certainly led me in that direction!)

The Setup

The basic signal chain to accomplish this is: Antenna -> INSPIRE receiver, Data Output -> microphone input on laptop. I used a simple stereo 1/8-inch audio patch cable between. The laptop is running Windows 11. There are two software packages we have used, both of which have freeware versions. One is Spectrum Lab, the other is Spectrogram. Spectrum Lab is usable right out of the box in some ways but refining the settings was a bit tougher than Spectrogram. I felt more comfortable tweaking Spectrogram but Spectrum Lab will have much more filtering ability once I get used to it. As mentioned above, we used several antennas. One was a simple helical whip on the BNC connector. One was a 3-meter wire with earth ground to the terminal strip. Finally, we ran some coax to a long-wire (100 ft) antenna, from the BNC connector.

Explaining the Concepts

Explaining the concepts of frequencies, broadband noise, RF and audio signals, and how they may be used to observe atmospheric phenomena to a pair of inquisitive 9-year-olds is not simple – they ask a lot of questions! So, I decided to take a phased approach.

Sound to image

First, we used Spectrum Lab out of the box with a microphone to show the concepts of visualizing audio signals graphically. They observed the different colors and patterns based on the sounds of their voices (and a few other things). This gave them an idea of how we might 'see' sounds. Figure 3 shows a

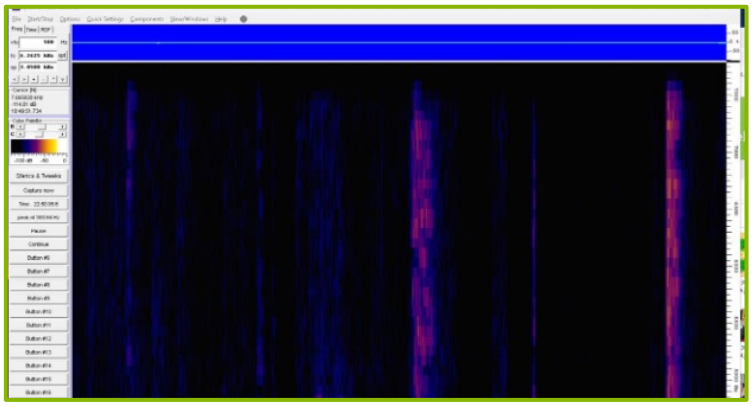
Figure 3: Audio Spectrum Graph Using Voices

result of this exercise. They understood the relationships between what they saw on the screen and the sounds to be related to signal strength, and they became familiar with terms such as frequency components.

Radio Signals to Sound

Then we listened to the audio from the INSPIRE receiver with no antenna using the headphone output. Even without the antenna, we detected noise from some lightning strikes. There were some storms towards the coast about 150 miles east. As a result, they got the idea of how the lightning created the noise as “crashes”. We also observed how getting close to a power source would generate some 60Hz signals. The INSPIRE receiver has very good filters built in to reduce this but when you get close enough it is certainly detectable. I explained to them that the background noise was from the AC electricity coming into the house over the power lines – and how it was basically a radio signal. And they of course got the correlation between electricity coming into the house and electricity from lightning strikes.

Figure 5: Nathan looking at the noise as an image.

Radio Signal Sound to Image

The next step in the concept chain is to relate the sound from the INSPIRE radio receiver to a visual image. We started up Spectrogram, which I had previously tweaked to try and get some good contrasts in the signal. (This for me was the hardest part of the whole experiment.) I used some of the examples on the INSPIRE website and in *The INSPIRE Journal* as guidance. Then we looked at the visual representation of all this noise! In the house there was quite a bit on the screen.

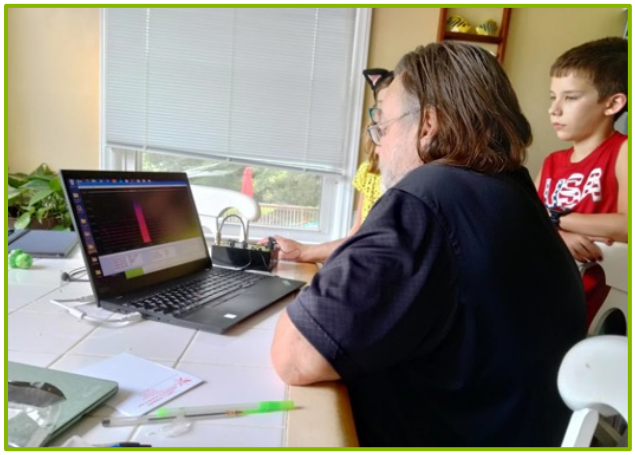

Figure 6: A Mysterious Spike!

Figure 7: Ashley visualizing the noise from the antenna.

Using INSPIRE VLF Receiver with Real Data

Now it was time to look at some real data from the INSPIRE receiver. I used a length of coax to a long wire antenna, with the shield grounded, from the BNC connector. The result was a pretty broadband swath of noise. We played with the colors and tried to emphasize the areas of interest. We did get to see a prominent spike (Figure 6), the origin of which I have no clue. Perhaps the refrigerator compressor kicked on!

Results

We then did a bit more with the colors and other parameters to tweak the image we were getting. The following two images show these adjustments. The twins gave some feedback to help me during this process. The first display was full of noise and colors. We could discern some spikes at regular intervals on the screen. The next image shows the spectrum with the filter off then on, then off again. I used this to demonstrate what the receiver could do to tune out some of the interference as well as what the interference could be from. We also used this image to understand what the lines represented – frequencies (left) over time (bottom) at certain intensities (colors). We talked about how the top yellow band

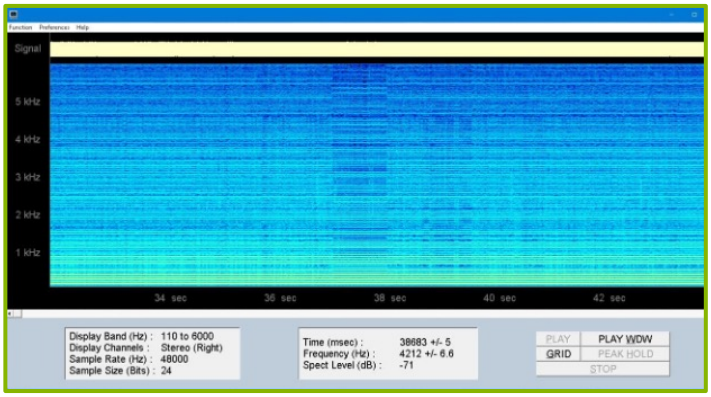

Figure 8: Lots of noise and lots of color.

indicated the overall signal level coming into the computer and how we could adjust it with the data control. And the spikes become a bit clearer. In this way the image started to show some of the natural signals as opposed to all the power line noise. The next step was to use web materials to explain how the different patterns in the data resulted from strikes at various distances reflected by layers of the atmosphere. Especially helpful were the explanations for spotting spherics, tweaks, and whistlers and samples on INSPIRE's website. As we were in the house at this point with an external antenna, it was not ideal conditions for listening and viewing. There simply is too much noise from the powerlines and other sources. Our plan was to go outside some distance from any of these; however, it turned out we did not need to…

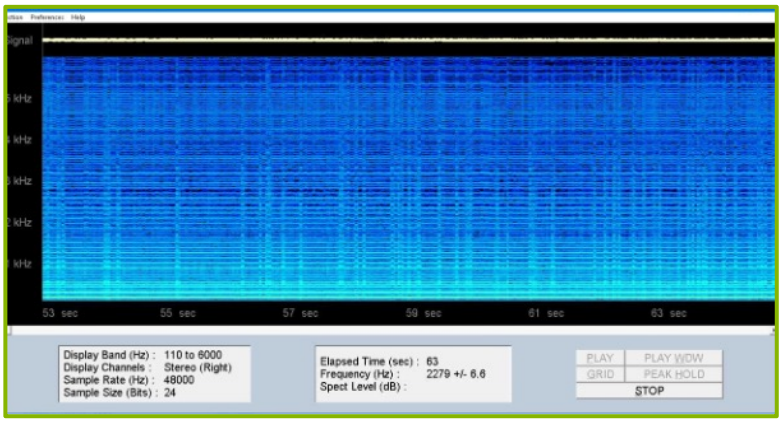

Figure 9: Starting to see some interesting artifacts.

A Fortunate Outage

At one point a power outage provided an opportunity to look in more detail about what was going on in all this noise. With no power in the general area, there was no need to isolate outside. I switched to a helical antenna right on the BNC connector since there was now no interference in the house. I would say this gave us a much more usable signal than the long wire in any event. We were fortunate to get some clean signals rather quickly. We correlated the crashes and pops in the audio, to what we viewed on the display. This display really made the correlation obvious. We discussed the spherics and tweaks, relating the noises we heard to the samples on the INSPIRE website to help identify what we were looking at. I then switched over to Spectrum Lab for some more observations. I found it a bit easier to tweak the background and foreground with the brightness and contrast controls. We were able to dig out some more of the signal this way. We identified the peaks and repeats of the spherics and tweaks, but also started to make out the sweeping curves of some whistlers. Adjusting the contrast a bit made them even more apparent. The whistlers were not readily detectable by ear, but they showed up in the data quite well as seen in Figure 11. There seemed to be a top and bottom to the sweep but not much in between. I assume this has something to do with the settings of Spectrum Lab and will warrant further investigation.

Figure 10: Spherics

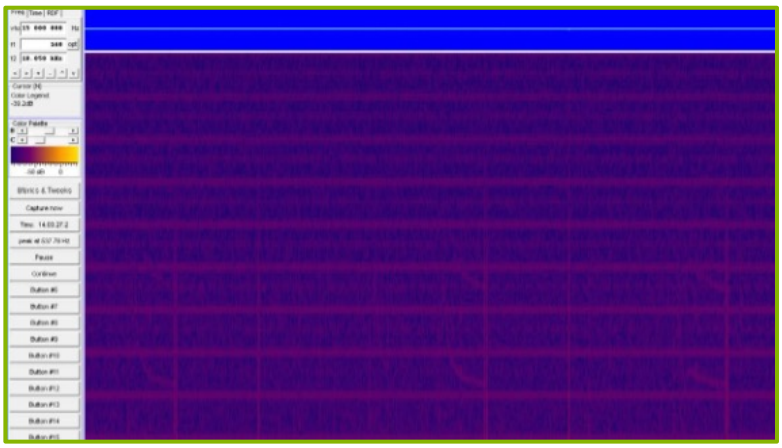

Figure 11: Adjusting the contrast to see the whistlers a bit more clearly.

When the power returned (and we had internet connectivity), we used Lightning Maps to hunt down the source of the signals. This is where we saw storm activity at the North Carolina coast. We are located in the Piedmont Triad region about 150 miles away. Additionally, there was activity quite a bit farther west. We discussed the fact that the strong spikes indicate the lightning close in, whereas the spikes which tapered off over time indicated strikes farther off which were dispersed. We discussed the meaning of this – that some parts of the signal will arrive at different times when it is far away, and that this occurs because some of the frequencies travel quicker than others. The signals actually bounce off the ionosphere, which they are a bit familiar with from watching one of the space missions. Of course, the ultimate illustration of dispersion is whistlers. We discussed the fact that these signals travel along a magnetic field line in order to return earthside, I was asked where these were coming from and of course I could not answer!

(Editor's Note: Whistlers originate from lightning. The electromagnetic pulse from lightning can travel back and forth along a magnetic field line between hemispheres. So observing whistlers in the northern hemisphere means that the radio frequency signal could have been generated by lightning in either hemisphere.)

The Reactions

There were not any Aha!, Eureka!, or Wow! reactions from the twins which I can report. I think if we were in the midst of a local lightning storm it might have been a bit more exciting. But there was a lot of interest and questions, which showed they understood the basic concepts of what was going on. For instance, while discussing the origin of the whistlers, the fact that one of their friends was on vacation in Kenya and the possibility of a signal coming from that location was discussed. They considered the possibility that planes overhead – or spacecraft being launched – could be detected in this manner. I am not sure how that would affect the results and told them so; we made a note for a future experiment.

In December of 2021, the Amateur Radio on the International Space Station (ARISS) team worked with the ISS crew to transmit Slow Scan TV (SSTV) images over amateur radio frequencies. These images commemorated Lunar Exploration. We used my amateur radio station equipment and SSTV software to detect and display the images. The twins observed how some of the images were of better or worse quality depending on where the ISS was in its orbit. Below (Figure 12) is a snapshot of one of the images with a bit of noise in it. Amplitude dispersion and reflection of the signal through the ionosphere is one of the causes for this noise, as well as tracking errors as the ISS passed overhead. We did this using the ISS tracker (https://spotthestation.nasa.gov/tracking_map.cfm) as shown in Figure 13. These activities tended to reinforce each other in our discussions.

Figure 12: Receiving images from the International Space Station.

Figure 13: Setup for receiving images from the ISS.

Conclusions

I was very happy with the results of this exercise and look forward to future activities with Ashley and Nathan using the INSPIRE receiver. The overall goal of stimulating and reinforcing their interest in science was well met. They understood most of what was going on as the concepts were explained, and they were able to relate the phenomena to other experiences they have had. They had good questions, not all of which I could answer but which I will work on in the future. Being able to listen to Earth through natural radio was fascinating to them; understanding what the different signals indicated was a bit like a game with the visualization aspect. They learned about frequencies, signal strengths, dispersion by the ionosphere, and how the Earth's magnetic field can affect signals.The idea that we were listening to lightning storms at great distances was exciting.

Future activities include:

- We will use the INSPIRE receiver during a localized storm to look at some baseline patterns.
- We will use the system at a more remote location, a mountaintop location in nearby Wilkes County.
- We will use the system during spacecraft launch to see if we can detect any interesting signals from that.
- We will relate the signal to other natural activities, such as earthquakes.
- We will investigate related information on spaceweather.com.
- We will follow The INSPIRE Project's activities and the VLF forum.

I appreciate the efforts that have gone into The INSPIRE Project – making the receiver kit available for use as a way to introduce people of all ages to natural radio and VLF signals. The twins and I are also working on the Project JOVE receiver to monitor signals from Jupiter. We will be building the antenna for this project on the mountain in Wilkes County. I look forward to other opportunities to utilize NASA offerings to advance their interests (as well as mine) in science and space.

I welcome any comments, questions, or feedback to: detschel@wilkes.net

A Tale of Two Eclipses (October 14, 2023 and April 8, 2024)

Mitzi Adams
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NASA Marshall Space Flight Center (Huntsville, Alabama)

A total solar eclipse happened on April 8, 2024; it is the last to occur over the contiguous United States for twenty years, with the next one occurring on August 23, 2044. This 2024 eclipse was the second solar eclipse in six months, the first being an annular eclipse on October 14, 2023. Looking at the maps of the two eclipse paths, the path of the annular eclipse crossed the path of the total eclipse, traversing the country from the northwest to the south, with the shadow moving onto land in Oregon and exiting the United States in Texas. The path of the 2024 total eclipse ran from southwest to northeast, entering the country in Eagle Pass, Texas and exiting in Maine. This article will describe these two eclipses, from the viewpoint of communities and locations in southwest Texas, specifically, Uvalde, Concan, Eagle Pass, and Del Rio, where we encouraged the study of science and engagement in citizen science.

[See the path of totality and the path of annularity respectively, at these two URLs:
https://www.eclipsewise.com/solar/SEgmapx/2001-2100/SE2024Apr08Tgmapx.html
https://www.eclipsewise.com/solar/SEgmapx/2001-2100/SE2023Oct14Agmapx.html.]

In 2017, the United States was treated to a total solar eclipse, the path of which spanned the country from the Northwest (Oregon) to the Southeast (South Carolina). This was the first total solar eclipse to be seen in the continental United States since 1979 (observable from Washington, Oregon, Idaho, Montana, and North Dakota), and the first to go coast to coast since 1918. Observers and media personnel from NASA's Marshall Space Flight Center (MSFC), Space Camp students from The U.S. Space and Rocket Center, students from Austin Peay State University in Clarksville, Tennessee, and students from the INSPIRE Project, and scientists, converged on several areas in Tennessee and Kentucky: Clarksville, Tennessee; Hopkinsville, Kentucky; and Guthrie, Kentucky. At those three sites, the scientists and students observed the eclipse and performed experiments (for complete descriptions, see The INSPIRE Journal, volume 23, Winter 2017/Spring 2018). Video from the Hopkinsville, Kentucky site was used on NASA's YouTube live stream (https://www.youtube.com/watch?v=nr4Sozvo5aU, at approximately 2:19:14).

What's the Big Deal and What is an Annular Eclipse?

An annular eclipse is simply a partial eclipse with very good press, but with a special aesthetic quality (see Figures 1 and 2). The word annular comes from the Latin word annulus, which means ring. Unless using projection methods (see Figure 9), observing an annular eclipse requires that eye and telescope/camera protection must always be used, e.g., solar-viewing glasses and specialty filters placed over the front of a telescope or camera; these greatly reduce the intensity of the sunlight reaching the eyes or camera sensor. This type of eclipse is so named because at greatest eclipse, when the Sun is mostly covered by the Moon, a ring (annulus) of sunlight is observed around the eclipsing Moon. Enough of the intensity of the Sun's light is still present though, so eye, telescope, and/or camera damage would result if filters were not used. When eye/camera protection is used, the effect is quite pleasing, as seen in Figure 1.

Figure 1: NASA/Bill Dunford, May 20, 2012, from https://solarsystem.nasa.gov/resources/2773/may-20-2012-annular-eclipse/?annular_eclipse

Figure 2: Annular Eclipse as seen from Garner State Park, Concan, TX on October 14, 2024. Photo by Mitzi Adams, NASA/MSFC and Lika Guhathakurta, NASA/HQ.

So why does an annular eclipse happen? Because the Moon as it orbits Earth, is not always at the same distance from Earth. For an annular eclipse, the Moon is at, or close to, its farthest distance from Earth, thus the Moon appears smaller than the Sun. The big deal is that total/annular eclipses over any one location on Earth, are rare. There are two reasons: 1. Most of Earth is covered in water and 2. paths of annularity are very narrow (and the same is true for totality), only about 200 km (124 miles). So finding a suitable location from where one can observe the eclipse is not always easy (or possible).

Eclipse Plans and Personnel for April 2024

Almost immediately after the 2017 eclipse, this author did what every eclipse studier does, she began planning for the NEXT eclipse. The first step of such plans is to determine the location from where the eclipse will be observed. To do this, maps such as the interactive Google maps mentioned above are consulted. Accuracy is important, since anyone outside a path of totality or annularity will not allow one to see the Sun's corona in the case of a total eclipse, or the dramatic "ring of fire" in the case of the annular eclipse.

For the April 8, 2024 total eclipse, NASA/MSFC and I established a small team to observe, provide imagery, and education/ outreach (Table 1). MSFC and NASA Headquarters (HQ) designated Russellville, Arkansas as a NASA "Sun Spot", from where a live feed would be generated (see https://www.youtube.com/watch?v=2MJY_ptQW1o at about 1:58:00), using the telescope and video skills of Joseph Matus, a NASA/MSFC manager who was part of the 2017 eclipse team in Hopkinsville, Kentucky. Dr. Robert Loper, a solar scientist and space-weather expert, served as a Subject Matter Expert (SME) from MSFC. However, my team decided, by examining the path of totality, factoring in the season (Spring), and the lower probability of clouds, that the majority of us would return to southwest Texas to the area crisscrossed by paths of annularity and totality.

Table 1: Solar Eclipse Team – Roles and Affiliations

Name	Role	Organization
Russellville, Arkansas		
Christopher Blair	Organizer/Public Affairs Specialist	NASA/MSFC Office of Communications
Todd Cannon	Organizer/Exhibits	NASA/MSFC Office of Communications
Jonathan Deal	Organizer/Public Affairs Specialist	NASA/MSFC Office of Communications
Dr. Robert Loper	Subject Matter Expert	NASA/MSFC Heliophysics and Planetary Science Branch
Joseph Matus	Telescope Operator	NASA/MSFC Program Planning, Human Landing System (HLS) Program
Southwest Texas Junior College Uvalde, Texas		
Dr. Paul Bremner	Subject Matter Expert and Telescope Operator	NASA/MSFC Heliophysics and Planetary Science Branch and Transform to Open Science (TOPS)
Garner State Park Concan, Texas		
Amanda Adams	Subject Matter Expert and Telescope Operator	NASA's Transform to Open Science (TOPS)
Adam Farragut	Subject Matter Expert and Telescope Operator	NASA's Transform to Open Science (TOPS)
Dr. Adam Kobelski	Subject Matter Expert and Telescope Operator	NASA/MSFC Heliophysics and Planetary Science Branch and Transform to Open Science (TOPS)
Lynn Purcell Student Activities Center Eagle Pass, Texas		
Mitzi Adams	Organizer and Subject Matter Expert	NASA/MSFC Heliophysics and Planetary Science Branch
Dr. Pete Robertson	Subject Matter Expert	NASA/MSFC Earth Science Branch – emeritus
Dr. Jennifer Miller	Subject Matter Expert/Organizer	Sul Ross State University
Brady, Texas		
Dr. Alphonse Sterling	Coronal Studies and Subject Matter Expert	NASA/MSFC Heliophysics and Planetary Science Branch
Dr. Tomi Baikie	Coronal Studies and Subject Matter Expert	Lindemann Fellow at MIT

On April 3, the week prior to the total eclipse, those of us in Southwest Texas began interactions with the community, and we did not stop until after the eclipse on April 8. We spoke to kindergarten and pre-kindergarten students, to high school and college audiences, and we even made a presentation at the Uvalde Honey Festival. In total, we estimate contact with 6000 to 7000 people, a number that includes students and the general public.

For science, we planned solar coronal observations (Dr. Alphonse Sterling and Dr. Tomi Baikie), temperature and humidity readings for the Global Learning and Observations to Benefit the Environment (GLOBE) Eclipse Program (Dr. Pete Robertson, Dr. Adam Kobelski, and Dr. Paul Bremner), and SunSketcher imagery to determine the "true" shape of the Sun (Mitzi Adams and Dr. Paul Bremner).

Dr. Sterling has for many years been researching solar coronal jets, which are very small (compared to coronal mass ejections [CMEs]) bursts of solar plasma. The research (see Sterling et al. 2015) has shown that these jets seem to work in a way similar to CMEs, but on a much smaller scale. Studies of jets are, in some respects, much easier than studies of CMEs since jets occur much more frequently. Since they are likely both driven by the same physical processes, understanding these jets could lead to predicting CMEs, which have the potential to disrupt radio communications, alter GPS accuracy, and adversely affect humans and assets in space. During a total solar eclipse, the corona of the Sun can be seen, along with plumes, feathery structures that emanate from polar regions that maintain their structure for many solar radii (see Poletto, 2015). Dr. Sterling is looking for evidence that plumes are initiated by jets (Raouafi et al. 2008), evidence that may be found during a total solar eclipse.

Since 1994, the GLOBE program has been training teachers, students, and the general public to make measurements of quantities such as air temperature, humidity, and sky conditions from locations around the world. With the advent of smart phones, data can be easily uploaded through the Globe Observer app. For the 2017 eclipse, over 10,000 observers collected more than 20,000 cloud observations and 80,000 air-temperature measurements using the app (see Figure 4 and https://observer.globe.gov/hidden/science-connections/eclipse2017). The app was made available again for the 2023 and 2024 eclipses (see https://observer.globe.gov/do-globe-observer/eclipse). We made no attempt to record temperature data for the 2023 annular eclipse, but for the total eclipse of April 2024, we obtained programmable sensors, similar to the one that recorded the data in Figure 3, to record air temperature and humidity. One sensor went with the Uvalde group, one with the Garner State Park group, and the last one went to Eagle Pass.

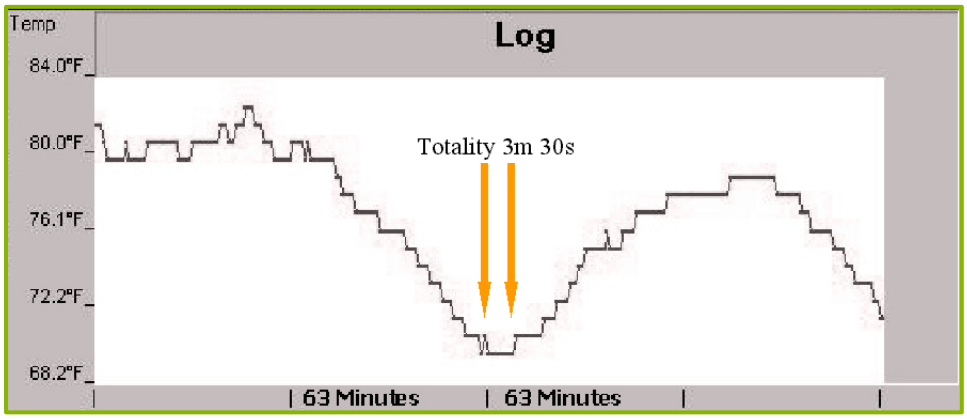

Figure 3: (left)
Temperature Drop, 28° C to 20° C (Δ 8°) [82° F to 68° F (Δ 14°)]
Data By Mitzi Adams, NASA/MSFC Solar Physics Group
Data obtained from roof top, Intercontinental Hotel, Lusaka, Zambia, June 21, 2001

Figure 4: (right)
Temperature Changes at APSU Farm in Clarksville, TN.
Minimum recorded was 27.8° C (82 deg F) at 1:30 p.m. CDT, a 9.2° C drop (from 98.6° F, Δ 16.6°)!
Data taken by Dr. Pete Robertson, NASA/MSFC, and students.
August 21, 2017

Sunsketcher is a citizen-science project led by researchers at Western Kentucky University whose purpose is to determine the "true" shape of the Sun. Researchers know that it is almost spherical, but there are deviations that represent motions and flows in the interior of the Sun. Because we know very precisely the location, height, and extent of the Moon's surface features (from the Lunar Reconnaissance Orbiter and Japan's SELENE satellite), those features that appear as Baily's Beads on the limb (edge) of the Moon during a solar eclipse can be used to map the solar shape.

Baily's beads are so named for an English astronomer, Francis Baily, who described the bright features he saw around the edge of the Moon

during an annular eclipse (1836). Baily described the phenomenon thusly:

> *"…a row of lucid points, like a string of beads, irregular in size, and distance from each other, suddenly formed round that part of the circumference of the Moon that was about to enter on the Sun's disc."*

Apparently, the beads had been observed by Edmund Halley during a solar eclipse in 1715 but were not as well described as by Baily. Both Halley and Baily recognized the cause of the beads, that the topography of the Moon (craters and mountains), either blocked or uncovered the surface of the Sun (Espenak, 2023).

Using data recovered from thousands of smart phones along with the topographic data from lunar-orbiting satellites will improve the accuracy of the solar-shape measurements. To learn more about Sunsketcher, visit their website https://sunsketcher.org/.

The View from Uvalde (and Brady) Texas

One thing about planning for and viewing a solar eclipse, is that flexibility is essential. We had planned for Paul Bremner (and family), Alphonse Sterling, and Tomi Baikie to observe the eclipse from the campus of Southwest Texas Junior College (SWTJC). But the evening before the eclipse the prospect of clouds over Uvalde convinced Drs. Sterling and Baikie to drive to the northwest to Brady, Texas, where the prospect for clear skies during totality was much better than in Uvalde. The gamble paid off for them, as can be seen in Figure 5 below. Unfortunately for Dr. Bremner and his family at SWTJC, they experienced the darkness of totality, but caught only a glimpse of the eclipsed Sun. Dr. Bremner took charge of the temperature/humidity sensor, and like the other two sensors, it was hung in the shade of a tree, approximately five feet off the ground.

Figure 5: Totality as seen from Brady, Texas, image by Dr. Alphonse Sterling of NASA/MSFC. The image has been rotated to match what was observed by eye.

Figure 6: Visitors to the campus of Southwest Texas Junior College (SWTJC) set up for the eclipse.

The View from Garner State Park

On the day before the total eclipse, April 7, the team met at Garner State Park early in the morning to assist with an eclipse and weather briefing. Dr. Kate Russo (at the front of the room and to the left in Figure 8) explained what to expect and how the weather could affect viewing. Dr. Pete Robertson (NASA-emeritus, atmospheric science) showed predictions for the following day and discussed how the eclipse could affect the weather. Following this discussion, the team set up equipment in the field to practice for the main event on April 8.

Figure 7: (right) Also at SWTJC, the Bremner family look to the sky with solar-viewing glasses, hoping for the clouds to part.

Figure 8: Dr. Kate Russo and Dr. Pete Robertson give an eclipse briefing the day before the eclipse, at Garner State Park. Dr. Russo has been investigating how observing an eclipse affects the human mind in Project Awe.

On Monday, April 8, Amanda Adams, Adam Farragut, and Adam Kobelski set up equipment as they had on the previous day and hung the temperature/humidity sensor in the shade of a tree, within sight of the team members, and they waited for the partial phases to begin.

Figure 9: (above) Cloudy skies on eclipse day! Amanda Adams shows Girl Scouts how a projection telescope works, which yields an image (figure to the right) of the eclipsed Sun.

Figure 9 shows a cloudy sky over Amanda who is showing two Girl Scouts and others, how to use a projection-type telescope. The projected crescent-Sun image is also shown in Figure 9, just prior to totality that began at 1:30 p.m. and ended at 1:34 p.m. In addition to answering questions about NASA and the eclipse, Amanda and Adam Farragut distributed materials and discussed NASA's Transform to Open Science (TOPS) program (learn more here: https://science.nasa.gov/open-science/), a program committed to the open sharing of software, data, and knowledge as quickly as possible in the scientific process.

Figure 10: (above) Adam Kobelski (foreground), Adam Farragut (smiling), and Amanda Adams (left behind table) are set up for the eclipse, are answering questions, and handing out NASA information to Garner State Park visitors.

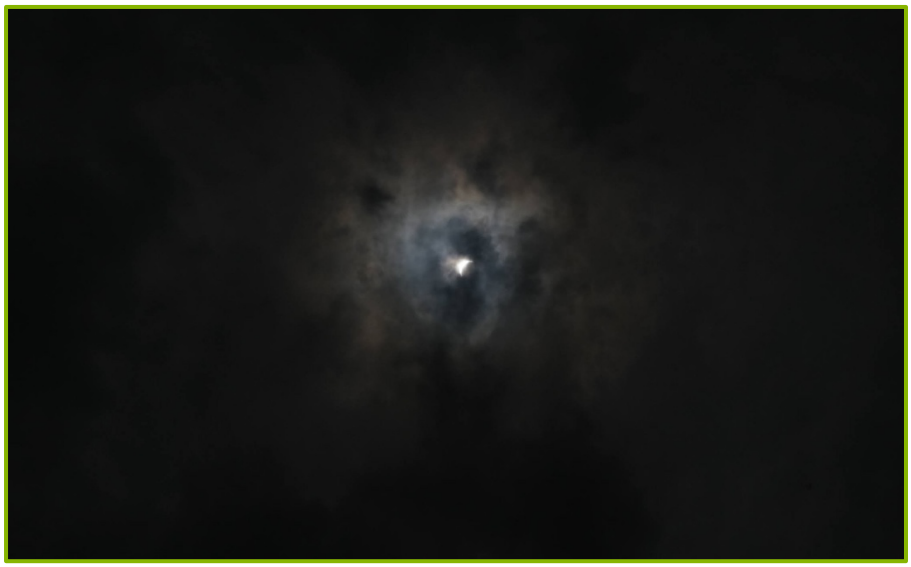

Figure 11: The partially eclipsed Sun, as seen through clouds at Garner State Park.

The View from Eagle Pass

The City of Eagle Pass is on the border between the United States and Mexico; it is about 60 miles southwest of Uvalde and about 90 miles southwest of Garner State Park. For the NASA team and a team from the National Science Foundation's National Solar Observatory (NSF/NSO) and the Laboratory for Atmospheric and Space Physics (LASP), our Sul Ross State University contact, Dr. Jennifer Miller, planned and coordinated contact opportunities with fifth grade, sixth grade, and high school-aged students.

Activities included working with magnets, creating art projects of the Sun, and viewing the Sun through telescopes. The event with fifth and sixth grade students took place on Thursday, April 4, four days before the eclipse. Note in Figure 12, the clarity of the sky. Fast forward to Monday, April 8 at the same stadium, when clouds cover the sky (Figure 14).

Figure 12: Students of the Eagle Pass Independent School District gather to experiment with magnets and create artistic representations of the Sun. Dr. Pete Robertson and Mitzi Adams ready telescopes.

In addition to the outreach to students, Dr. Miller and others organized an “Eclipse Cultural Conference” that was open to the Eagle Pass community. This event had the format of a panel discussion and included previously collected questions. Each panelist was given a few minutes at the start of the event to introduce themselves and to present views and beliefs about eclipses from cultures around the world. Special attention and respect was given to Native American ideas, such as the Navajo view that during an eclipse, one should not look at it, but should thoughtfully and quietly wait for the Sun to be “reborn” and paint the world with color.

Figure 13: On stage seated from left to right, Mitzi Adams (NASA/MSFC), Dr. Ryan French (NSF/NSO), Marcel Corchado (UC Boulder), Dr. Maria Kazachenko (NSO/LASP), Dennis Tilipman (UC Boulder), and a representative from the Kickapoo tribe. Dr. Alicia Trotman of Sul Ross State University is standing.

Figure 14: (left) Visitors to the Eagle Pass Sports Complex gather to witness the eclipse. (right) Solar System Ambassador Derek Wallentinsen (orange shirt) sets up his equipment and answers questions. Dr. Robertson (by fence) checks the weather radar with his phone.

Set up at Eagle Pass included a 3.5-inch Questar, a 5-inch Celestron, NASA handouts, and a temperature/humidity sensor. Dr. Robertson hung the sensor in a tree in shade with multiple signs requesting visitors not to touch the sensor or remove it. At the end of the partial phases following totality, we removed the sensor and stored it for data download later.

Results and Lessons Learned

All three of our planned sites had clouds, before, during, and after the eclipse. As mentioned previously, Drs. Sterling and Baikie left Uvalde and drove to the northwest to Brady, Texas, where they were able to capture approximately one minute of totality. Observers in Uvalde and Garner State Park experienced total darkness but caught only a glimpse of totality. In Eagle Pass, fortune smiled upon us as clouds parted just as totality began and clear sky prevailed around the eclipsed Sun for the four minutes and nearly thirty seconds of totality.

Figure 15: Solar System Ambassador Derek Wallentinsen captured this image of the eclipsed Sun from Eagle Pass, Texas, where he aided with crowd interactions.

Since finding the Sun, centering its image in the field-of-view of a telescope, and focusing relies on a few minutes of time without clouds, it was extremely difficult to set up equipment. Each time this author had the Sun in the field-of-view, a cloud would obscure the image making it impossible to focus. Fortunately, our Solar System Ambassador representative, Derek Wallentinsen, was able to focus during totality while I spoke to onlookers. A family of three with a three- or four-year-old girl saw the eclipsed Sun with their eyes, as well as through Derek's telescope (see Derek's image – Figure 15). Note the large prominences, plasma confined by loops of magnetic field. Sometimes these prominences erupt, which may have been the case for the prominence at about the 3:00 (three o'clock) position. A better view of that prominence is seen in Linda Rawlins (NASA-emerita, computer and internet specialist) image (Figure 16). The prominence at the 5:30 position is the largest unaided-eye prominence this author has seen. Estimates of its size indicate that it would take approximately 3.5 Earths to reach the visible height of the prominence (as measured from the "edge" or "limb" of the Moon).

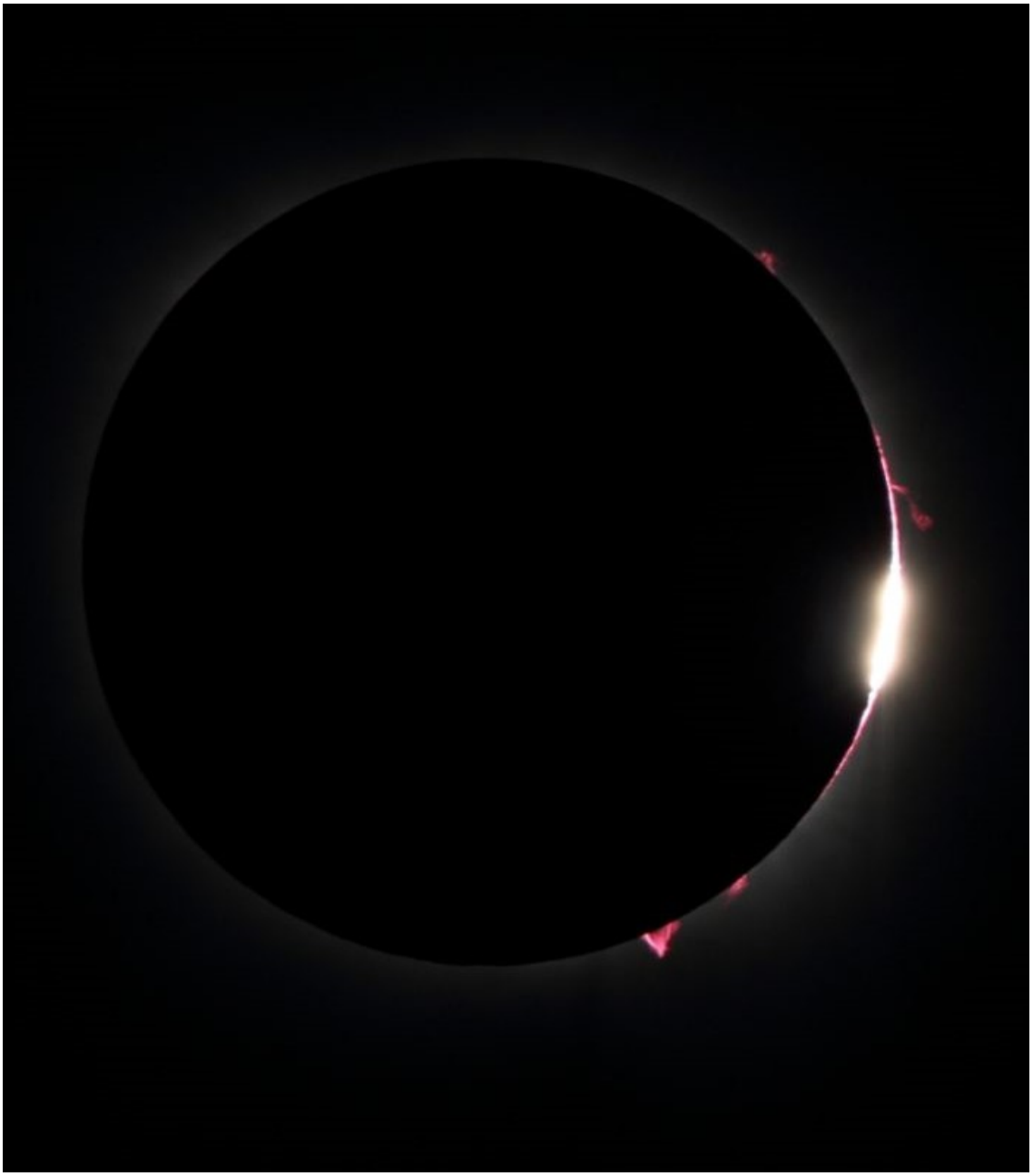

Figure 16: Image from Mansfield, Texas, by Linda Rawlins, NASA-emerita. Note the prominence above the "beads" at about 3:00. This prominence is possibly in the process of erupting or has erupted and is beginning to decay.

We set up temperature/humidity sensors at each of our three sites Uvalde, Garner State Park, and Eagle Pass. The team at Garner State Park had visual access of the sensor until just after totality when they noticed that the sensor was missing. The team checked the ground, trash cans, and notified Park personnel of the missing sensor, in case it should turn up; it did not. The two sensors at Uvalde and Eagle Pass were retrieved and taken back to MSFC in Huntsville, AL for data recovery. In spite of testing the programming before the eclipse, the sensors did not stop recording when the eclipse ended, so all data were over written. Our efforts to record temperature and humidity data at three separate sites failed.

With regard to SunSketcher, after some difficulty, Dr. Bremner was able to upload data to the server at Western Kentucky University (WKU). Ms. Adams (Mitzi) at Eagle Pass started the SunSketcher app, saw that it was running, pointed her phone's camera to the Sun as instructed, then forgot about it till just after totality (also as instructed). Checking it then to upload the data, she saw that the app had strangely closed. As usual, everything that can go wrong, will! However, the project reports that almost 40,000 users downloaded the app and about 3,000 granted permission for their data to be uploaded, with excellent geographical coverage of the path of totality. To analyze the data, the team (led by Dr. Gordon Emslie at WKU, with support from Dr. Hugh Hudson of Berkeley, U. of Glasgow, and WKU) will use a model of the solar-limb profile from the Lunar Orbiter Laser Altimeter (LOLA) database and will compute the locations and intensity/time profiles of Baily's Beads at the exact time

and location of each observation. This will be compared with actual timing of the Beads and the solar-limb profile will be adjusted accordingly. Check the SunSketcher pages (https://sunsketcher.org/) frequently for updates.

Dr. Jennifer Miller of Sul Ross State University collected data on the impact the solar eclipse had on viewers at the Eagle Pass viewing location. A sample of questions and responses follows (116 respondents).

1. How interested are you in this solar eclipse activity?
   1 = Not at all, 2 = Somewhat, 3 = Partially Interested, 4 = Interested, 5 = Extremely Interested. ***69% of respondents were extremely interested.***
2. To me this STEM activity was: _____ (unexciting 1 2 3 4 5 6 7 exciting). ***61% of respondents reported exciting.***
3. This solar eclipse activity could encourage students to have a career in: (choose one)
   Science, Technology, Engineering, Math, Other. ***The majority of respondents, 88%, chose Science.***

In the week leading up to the eclipse, Dr. Miller and the MSFC team did multiple presentations for school children in the Uvalde, Eagle Pass, Del Rio area. Dr. Miller's intent was to survey the children in the Eagle Pass Independent School District (EPISD), but the administrators decided not to send out the survey, since it would require parental consent as well. However, district data from state testing will be publicly available later in the summer of 2024.

Regarding lessons learned, all instrumentation should be clearly labelled with "do not touch" signs or something similar. Selecting good sites for viewing an eclipse must continue to evaluate the probability of clouds along with ease of access and availability of resources at the site. Those who are involved in scientific observations of the Sun must be ready to travel at the last minute to a less cloud-covered area. Be certain that if experiments rely on mobile phones, the phone's operating system has been updated to the most recent version, and of course, charge the phone ahead of time and/or be certain that power is available. Finally, if possible, arrive at the viewing site *at least a week* in advance to have an opportunity to interact with the community, share opportunities for the community to be involved in citizen science, and practice with equipment.

Now, as is usual for eclipse afficionados, plans are being made for the 2026 eclipse that will cross over Iceland and Spain yielding about two minutes of totality. But the big push will be for the 2027 eclipse that will cross Egypt. That eclipse is projected to have over six minutes of totality! The longest possible is seven and a half minutes. *Where will you be?*

Author's Note: NASA challenges everyone to participate in as many Sun-related activities as you can as part of NASA's Heliophysics Big Year. Multiple citizen science projects continue, there are monthly themes, from fashion (!) to visual art to solar cycle and solar max, and the Big Year culminates with Parker Solar Probe's closest approach to the Sun on December 24, 2024. **For more information, and to find out how you can participate, visit these pages: https://science.nasa.gov/sun/helio-big-year/**

Acknowledgements: This author thanks the Team for extremely useful suggestions for the text with special gratitude to Joseph Matus, Linda Rawlins, Adam Kobelski, Bob Loper, Alphonse Sterling, and Eva Kloostra.

About Mitzi Adams

Mitzi Adams is the Assistant Manager of the Heliophysics and Planetary Science Branch at NASA's Marshall Space Flight Center (MSFC) in Huntsville, Alabama. During her research career, she has studied 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.

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2024 - 2025 INSPIRE Educational STEM Programs

College / University Scholarships

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

Scholarship Awards: Up to $4,000 per recipient
Application Deadline: December 31, 2024

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: http://theinspireproject.org/default.asp?contentID=5*

Eligibility Requirements

- U.S. citizenship
- 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 will help you advance in STEM disciplines and the positive impact it will have on your future

NASA Goddard Space Flight Center aerial photo courtesy of NASA

College / University Internships

2025 NASA Center or Facility Paid Internships

Paid Spring 2025 Internships
Internship Session: January – Mid-May

With support from the District of Columbia Space Grant Consortium and other partners, The INSPIRE Project offers paid internships at NASA Centers and Facilities. NASA 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-work task completion. Through these internships, participants engage in scientific or engineering research development, and 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

- 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 internship applicants must be undergraduate or graduate students enrolled at a college or university in Washington DC

For complete information, to view current intern opportunities and to apply, visit the official NASA website: https://intern.nasa.gov/.
Note: After completing NASA online internship application, please email: info@theINSPIREproject.org so INSPIRE can confirm receipt of your application with NASA Office of STEM Engagement.

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

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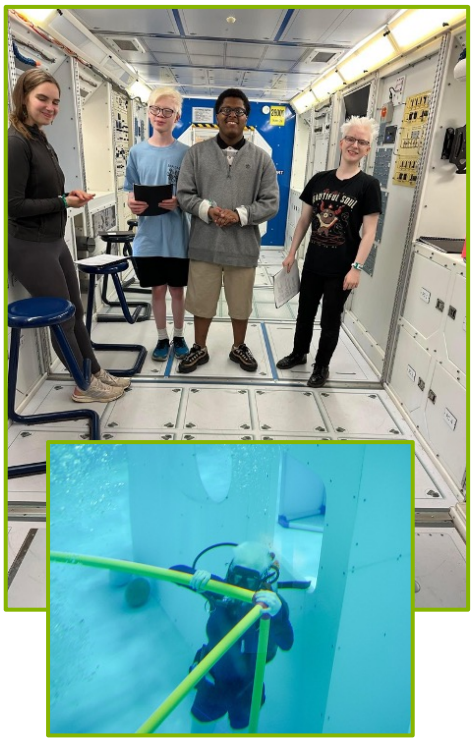
U.S. Space & Rocket Center | International Launch Services | Space Ad Agency | Fisher Space Pen

INSPIRE Space Academy Scholarship Recipient Shares Her Experience Attending Space Camp for Interested Visually Impaired Students

Elektra Larson

My name is Elektra Larson and I am a high school junior, aspiring aerospace engineer, and three-time attendee of Space Camp for Interested Visually Impaired Students (SCIVIS). I am a student in McKinley Technology High School in Washington DC, a STEM school with programs in engineering, biotechnology, computer science, and digital media. There I take classes in engineering to get a head start for college, where I plan to study aerospace engineering. My interest in space however, started long before I started high school; in fact, I can't remember a time when I wasn't interested in space. I remember being fascinated by space as a child; my favorite book was one that explained the formation of the universe, but what really got me interested was when my parents showed me Star Trek. I first saw it when I was five years-old but wasn't really invested in it until I was thirteen, the same year that I decided I wanted to become an aerospace engineer. The next year was my first trip to Space Camp, and from that point on there was no going back.

Why I Attended SCIVIS



When I was fourteen, I was offered the chance to go to Space Camp and jumped on the idea. At that point I didn't know what it would entail, but my recent obsession with all things space pushed me to go. I would come out of that week with an exponentially greater interest in space exploration, a determination to work for NASA when I grew up, more friends than I have made at my high school, and excitedly telling everyone I could find that it had been the best week of my entire life. As someone with albinism I am legally blind, only having roughly 20/200 vision; this often makes it difficult for me to participate in group activities, especially sports. SCIVIS meanwhile, is an environment where everyone else has the same difficulties as me; all knowing the struggles of going through life in a world that wasn't made for us, and where everyone else knows something we don't. There's an intrinsic understanding that comes with that; we are able to relate to each other on a deep level and we know each other's struggles and how best to provide assistance. SCIVIS is also specifically designed for us to accommodate our lack of vision, an opportunity to fully engage where we would ordinarily be listening on the sidelines. I am not the most sociable person – I only regularly hang out with two people at my high school after three years in attendance. In contrast, at Space Camp I'll be excitedly talking to five different people. It's one of the only times I get to hang out with a bunch of other space nerds – many of whom plan to pursue careers in aerospace engineering, astrophysics, or some other similar field. I maintain relationships with them to this day, talking with them about our plans for college or about the latest in space related news. I never had the opportunity before to meet such a concentration of people with similar interests. As we collectively head off to college in the coming years, I hope to maintain our relationships; one day we could even end up working together. Of course, it isn't just the friends I've made that keep me coming back every year, it's the content as well. An entire week dedicated to activities and learning about, and activities about, space! I've experienced many things there that I never would have gotten the chance to otherwise, particularly because I (for now) won't be able to become an astronaut. I'm lucky that I go to a high school where I can take an aerospace engineering class, but Space Camp is truly a chance to immerse myself in my favorite topic. I really have learned a lot there, and there I would highly recommend space camp to anyone who is remotely interested in space.

What is SCIVIS?

SCIVIS is a 5-day program held each October at the US Space & Rocket Center in Huntsville, Alabama. As stated above, it is specifically designed for visually impaired students with the materials and activities adapted for our specific use. It's nice to have the opportunity to be in an environment where we don't have to worry about what we don't see, and the staff all know how to deal with our vision issues – which is refreshing to say the least. To people who have had to spend much of their lives sitting out of many activities, or resigning themselves to very simplified versions of them, it's amazing to get to fully participate. One of the primary ways they adapt Space Camp for us is by providing braille and large print scripts for our missions. That in and of itself is highly appreciated – especially for the fully blind among us – but they also put braille and large print labels on the panels, switches, and other equipment we might use. It wasn't just for the missions either. Whenever we had to do an activity that involved paper, they provided large print and braille copies for us and a detailed verbal explanation if necessary. Another thing they did for us was to provide tactile models as opposed to visual images that would be used for other groups. While learning about cosmic phenomena, we were provided with 3D printed representations of galaxies and nebulae. For planetary astronomy, we received textured globe models of the moon and were guided through the different craters and seas by instructors. These topographical moon maps were particularly useful. I think they are actually a far better way to represent the moon than purely visual forms – they presented the shape and depth of craters far better than images. Additionally, they provided us with tactile images of planets and constellations – which even to a person with fairly functional vision, are greatly appreciated. Probably the most unique experience they adapted for us was the planetarium show. Though I had attended (and been able to see relatively well) multiple planetarium shows, none were as cool. The show was called *Sounds Of Space* which used music from different instruments to represent the different gasses of nebulae and astronomical phenomena, allowing us to understand their shapes without looking at them. Besides merely being a non-visual display, it also communicated the beauty of space. It was truly a joy to listen to and I'm sure it was incredibly helpful for my fully blind peers. I think one of the most impactful activities I partook in was the rocket launch activity; it inspired me to revive my school's rocket club after low attendance ended it. For once I didn't have to struggle through pictographic instructions too small to see; rather, we were given detailed verbal instructions allowing the blind attendees to participate as well. Getting to launch them was of course the best part, and though we weren't able to see them after they were launched, the sound is the best part anyway. Typically, visually impaired students would generally have far more trouble participating in these types of activities, but SCIVIS provides the accommodations we need to fully partake.

My Plans for the Future

As it stands, attending Space Camp is the closest I can get to actually going to space; I intend for that to change, and if no one else will change it, I will do it myself. There are two main problems I face in my personal mission to go to space: the difficulty of space travel and the fact that I am visually impaired. I have come to the conclusion that if I can't go to space, I can at least work to make space travel easier; some time in the future I hope space travel will be easy enough for anyone, regardless of disability, to go to space. For the longest time I had no particular desire to go to space – Space Camp changed that. Going there I heard all the stories of astronauts going to space, I learned about the history of the space race, I got to experience simulated missions, and every year the exhilaration and anticipation grew. The thought that I could do these things in real life consumed me – I had always really liked space, but I wasn't dead set on it. A couple years ago going to space was still a Star Trek-fueled fantasy but now it has become my life goal, and Space Camp is a large part of that. Every day at Space Camp I looked forward to the next. Every year I eagerly awaited the next year of Space Camp. Now, with my last year at Space Camp coming up, I know I will miss it but I also look forward to that day that I will be going to space for real.

The Amazing 2024 Total Solar Eclipse – My Three Takeaways

Dr. Gordon Telepun (FoxwoodAstronomy@gmail.com)

Within the span of seven years, the continental United States contained the path of two total solar eclipses. This allowed millions of people the chance to witness two total eclipses without the need for international travel. For people who saw 2017 and then saw 2024 as their second eclipse, I feel sure they thought the experience for each eclipse was different. For me, this was my sixth total eclipse, and I have learned that each eclipse is unique; there is no doubt about it! I would like to point out three things that interested me about 2024. Based on my experience with multiple eclipses, the 2024 eclipse deserves discussion of the weather, the view of totality, and some ambient lighting data and science.

The Weather

The 2024 eclipse provided the perfect example of historical weather data being helpful for planning but also being meaningless on eclipse day. Jay Anderson's data clearly made Mexico and Texas look like the prime viewing locations based on historical cloud cover. His map shows a higher risk of poor cloud conditions as you move through the center of the country toward the northeast. Millions of people planned to go to Texas based on historical data.

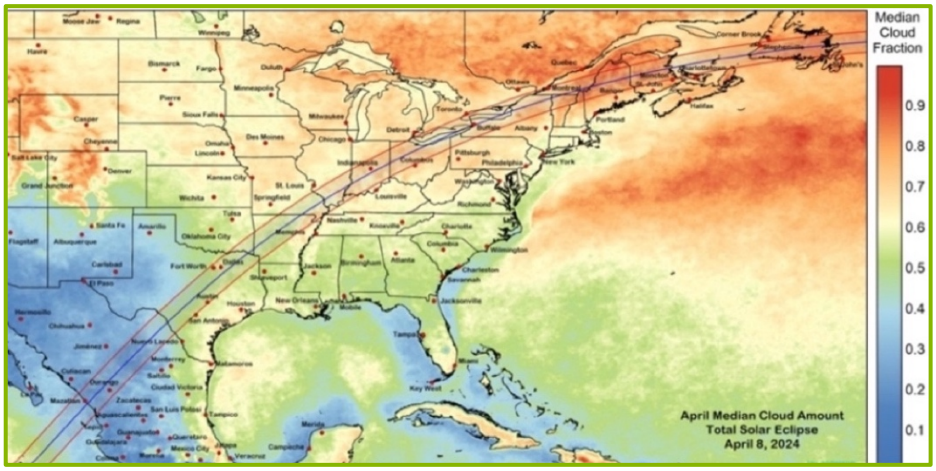


Figure 1: Historical cloud cover. Blue is good, green is fair, and red is risky. Image Credit: https://eclipsophile.com/2024tse/

I also chose Texas as my primary observing site, reserving accommodations for my group over a year before the eclipse. But, not trusting the April weather and determined not to miss this eclipse, I also reserved accommodations in Missouri as a secondary observing site. Four days before the eclipse, after monitoring the cloud prediction models, I chose to go to the Missouri site. We had clear skies and had a wonderful eclipse day. The conditions in Texas ended up being marginal.

On April 8, eclipse day, the cloud cover was almost the exact opposite of the historical predictions, with the southwest being cloudy, conditions acceptable in the central U.S., and the clearest skies being in the upper northeast. This eclipse showed why you never limit yourself to a single observing site for eclipse day, especially for a domestic eclipse with opportunities to be mobile. I know people who made a mistake in 2017 because they lived in the path, did not make alternate plans, and got clouded out. I am sure those folks, and others, learned a lesson, and for 2024, had observing site options or planned to stay mobile. The next couple of decades of total solar eclipses will require international travel, making alternate site options much more difficult.

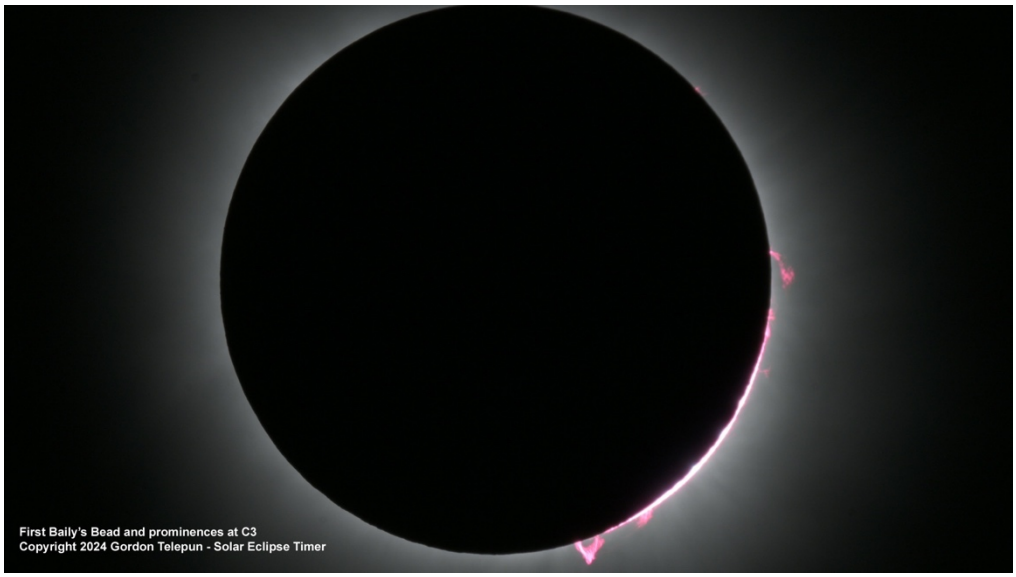
Figure 2: On eclipse day, the center of the country and the extreme northeast had the best conditions. Base Satellite Image Credit: https://home.pivotalweather.com/

The View During Totality

Every totality appearance is different. It's wonderful to be surprised by the shape of the corona when it comes into view. Being very close to a solar maximum in 2024, the shape of the corona was predicted to be more symmetrical and this ended up being correct. The coronas I witnessed in 2017 and 2019 were much more asymmetric.

Figure 3: (right) High dynamic range image of the corona revealing symmetry, Earth shine and the red glow of prominences.

During totality in 2024, the entire country was lucky to observe something extraordinary. A huge triangular shaped prominence was visible to the naked eye in the region of the lower pole of the Sun.



This was the most spectacular thing I have ever seen at an eclipse! Looking up at the eclipsed Sun with your naked eyes and seeing that pink prominence within the inner corona was amazing. Eclipse photographers were excited to image it. But what occurred to me as special was that casual eclipse observers were able to witness that view. It was spectacular and I am thrilled that so many people were able to enjoy that.

Figure 4: The first Baily's bead and prominences at 3rd contact.

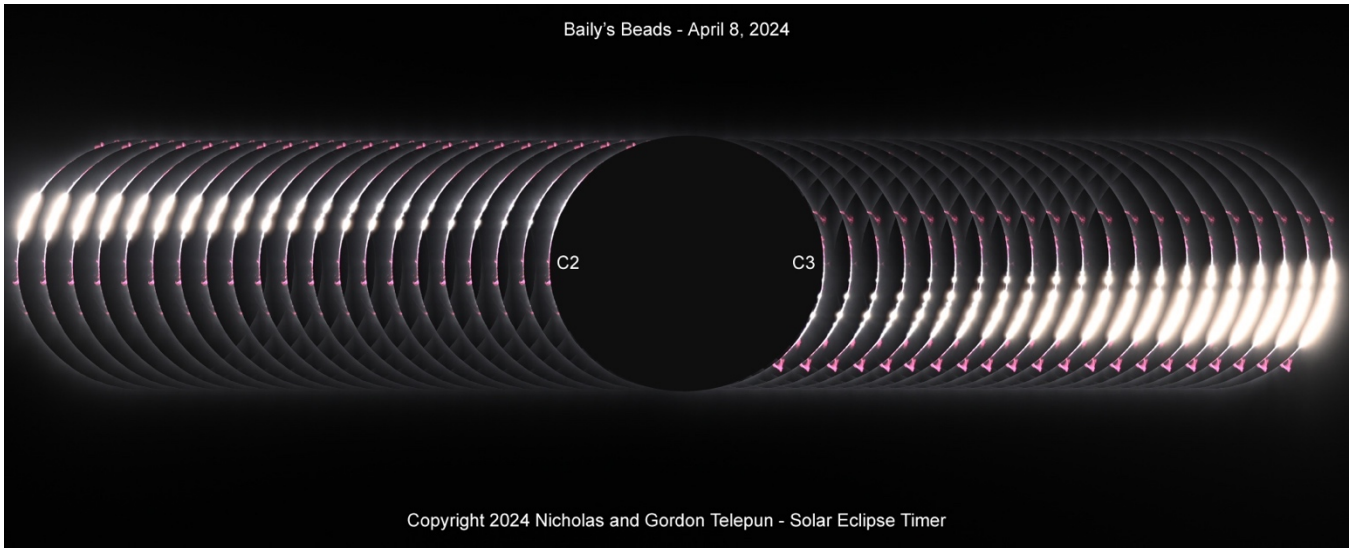


Figure 5: The complete progression of Baily's beads. The large triangular prominence becomes visible as the Moon moves.

Ambient Lighting Data

Part of my enjoyment at a total eclipse is monitoring some of the unique thermodynamic and optical effects that an eclipse creates. I monitor things like the temperature, the change in the character of shadows, and the lighting during the eclipse. For lighting, I monitor ambient color changes and LUX.

Since this eclipse occurred during solar maximum, many solar scientists, based on their knowledge and experience, predicted that the corona would be brighter. I was interested in seeing if this would be true and wanted to document it by measuring the LUX (Pasco 403-199 wireless light sensor) at the observation area. In 2019, I measured the observing area LUX. That was a 2m 30s eclipse; totality was 11° above the horizon, had an umbra diameter of 88 miles, and I was close to the centerline. The lowest LUX recorded, at totality, was 1.97 LUX.

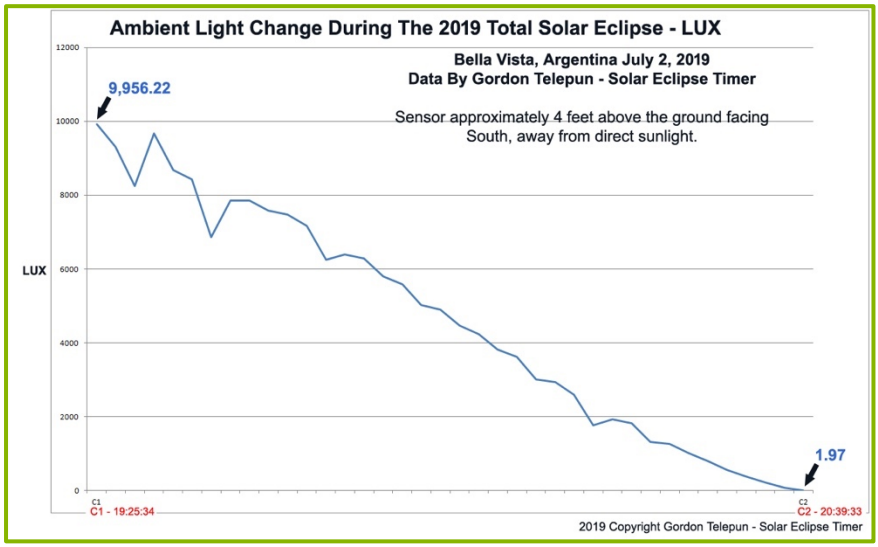


Figure 6: LUX data for the 2019 total solar eclipse.

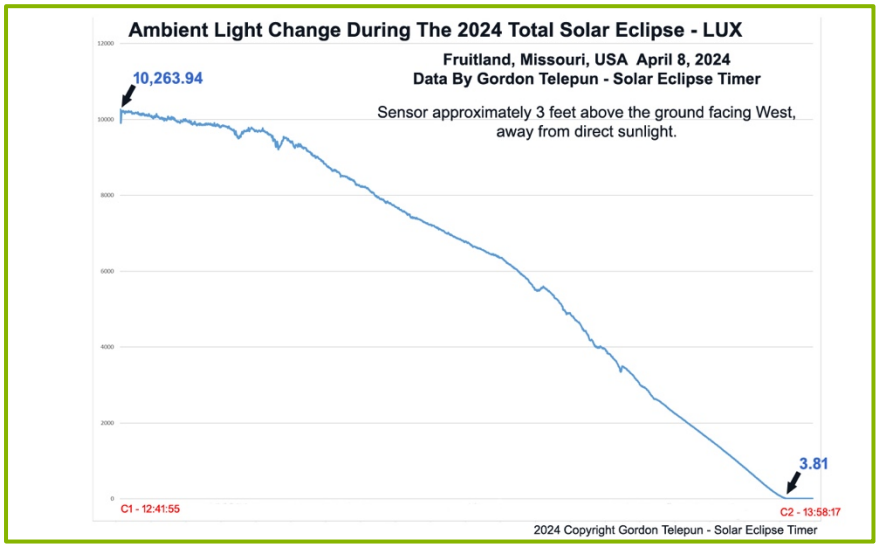


Figure 7: LUX data for the 2024 total solar eclipse.

The 2024 eclipse had a duration of 4m 23s, totality was 57° above the horizon, had an umbra diameter of 120 miles, and I was again close to the centerline. With a larger diameter umbra, and therefore being further from light coming from the horizon, what LUX would I record at the observing site? I set up the same LUX meter in a similar way (to 2019), and the lowest LUX recorded, at totality, was 3.81 LUX. So, this corona, close to solar maximum and at a higher altitude, resulted in a brighter observing site during totality when measuring the illumination on Earth in LUX.

Summary

The 2024 total solar eclipse presented cloud cover challenges along the path on eclipse day. But overall, it was a great day, and millions of people were able to enjoy the eclipse. The next total solar eclipse that crosses the entire mainland of the United States is on August 12, 2045. That path will start in Northern California and exit in Southern Florida.

About Dr. Gordon Telepun

Dr. Gordon Telepun is a plastic surgeon who lives in Alabama. He is an expert eclipse photographer, eclipse educator, and the developer of the mobile app Solar Eclipse Timer which is designed to be a personal guide and photography assistant through the stages of an eclipse. It has been used with great success.

In preparation for the 2024 eclipse, he published a comprehensive eBook on solar eclipses titled: Eclipse Day 2024 and More! How To Enjoy, Observe, and Photograph A Total Solar Eclipse. The preparation information in the book applies to all upcoming eclipses. For more information about his book or his mobile app, visit: http://www.solareclipsetimer.com.

(right) Gordon Telepun photographing the 2019 total solar eclipse in Bella Vista, Argentina.

INSPIRE VLF-3 Receiver Assembly and Field Tips from Bangkok

Peter Wright, HS0ZOG (Bangkok, Thailand)

I am 62 years-old and when in my thirties, I was deeply into VLF as well as other earth science modes like flux gate magnetometers. Back then I built from schematics my own McGreevy design VLF receiver and spent many happy days listening to the Dawn chorus and our Ionosphere. A typical fun day was centered around observing Meteorite storms like the Perseids or any other good excuse to spend the night out. You need to plan way in advance, and you need good friends, a good meteorite shower, a good location up on a hill, a midnight picnic, blankets, enough to drink, a digital video camera tripod, a VLF receiver, and a good place to get an early breakfast. The German word for Meteor is Stern Schnupper and you can probably imagine a hill fill of idiots shouting “SCHNUPPER” all night long. It was very funny and kept the cows, that we did not see until daybreak, around us entertained.

When discovering the INSPIRE VLF Version 3 kit on the Internet, I had a little smirk on my face of ‘Seen it, been there, done it, great memories, let’s do it again. Version 3… Hmmm interesting, let’s have fun and order a kit.’ After placing my order, I enjoyed emailing with INSPIRE’s program manager Eva until the kit finally arrived in Thailand. Opening it up, I noticed the loving dedication to bungling the parts in plastic bags and it gave me the good old American “Heathkit” feeling while putting it together. Here are my tips that will hopefully assist you in the kit assembly process.

Not Getting Parts Mixed Up

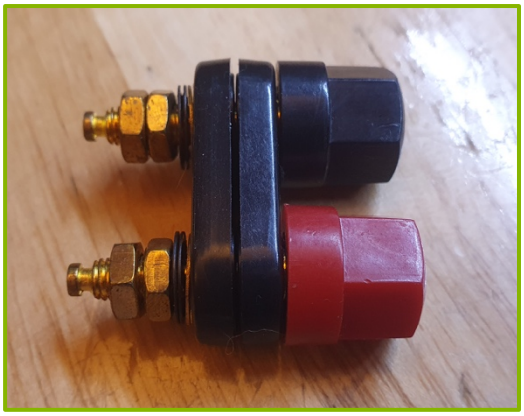
Get yourself a piece of polystyrene foam and break off a bit to place on the table. Now take a felt tip and mark with small spacing the numbers 1 to 28 on it. Place all the resistors on a plate so they do not role off the table and arm yourself with a multimeter. Print out the INSPIRE Kit Assembly Instructions and using the resistor color code on page 10, identify a resistor you pick up using the code. To avoid mistakes measure it with your digital voltmeter set to ohms. Obviously, the resistors are not exactly 10 kilo ohms so the value will be very close but not exact, using the digital meter however will make sure you are by hundreds of ohms, kilo or tens of kilo ohms or mega ohms and that is the trick. Now stick the resistor you have correctly identified and checked into the foam in its position 1 to 28, proceed until all resistors are sorted. Next, do the same general process for capacitors. This is not in the INSPIRE Assembly Instructions but can help you avoid making mistakes.

You will find the resistor code all over the place as being useful, like numbering wires by color.

Below is a little rhyme to remember it by:

0	Black	Billy
1	Brown	Brown
2	Red	Revives
3	Orange	On
4	Yellow	Your
5	Green	Gin
6	Blue	But
7	Violet	Values
8	Gray	Good
9	White	Whiskey

The next tip is in soldering the 2 LEDs, it is best to place them the right way round and bend over the tips of the wires so they do not fall out, but not to solder just yet. Do this when you assemble the board to the front panel, place the LEDs into the 2 holes to get the right length then solder.



The Version 3 VLF kit is extremely well designed, but it can still be tweaked. Pictured on the right, is an available version of 4mm Banana connectors fitted to a black 2 part insulating spacer mount. I decided to skip using the delivered screw terminal block in favor of this. It fits perfectly in the front panel cut out as it grips the aluminum plate left and right. Just make sure you see the half of the 2 bolt holes left and right when clamping, this will ensure that both terminal bolts do not short to the front panel. Red for ANT; black for RTN used as a ground. I got a little smile on my face when fitting the 2 knobs that just clear the edge of the black case – that's precision engineering folks.

Front Panel

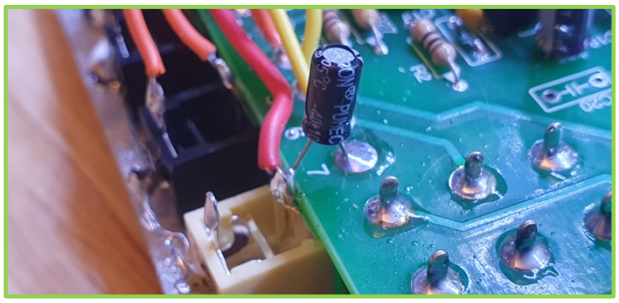
Where the assembly instructions were not clear to me is explaining how the 3.5mm audio jack's function, and to be perfectly honest the silk screen printing does not help, so in this section I would like to go into depth explaining this and a small modification I made.

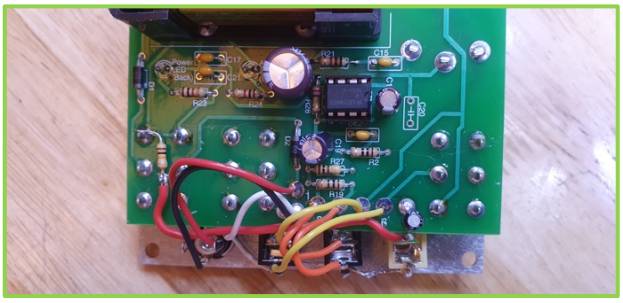
Using a Brother P-Touch Label Machine, my personal favorite, set to 6-point size, I printed out my new labelling.

The first thing to understand is that the INSPIRE VLF Receiver pushes out 2 voltage levels a low level centered around the standard Mic level of around 1mV and a much higher one which can drive headphones or an AUX input level of around 1V peak to peak. The required level you can adjust independently with the 2 potentiometers on the front panel. This higher level however is only active if the Audio power switch is in the up position so saving battery power if you are using a 9v dry cell. When assembling, I cannot stress highly enough how important it is to use the top picture on page 25 of the instructions to solder the wires correctly. Please note the white Mic 3.5mm socket is mono but where you can really screw up is soldering the orange and yellow wires. They select left and right channels which does not matter on the middle 3.5mm socket but is a real screw up on the so-called data socket. What I personally just did not understand at first was the function of the Mic/Data Switch, the 3.5mm jack standard is as follows: The tip is connected to the left-hand channel, the ring is connected to the right-hand channel, and the case is the common ground. What happens on the INSPIRE unit is this – the tip or L is constantly connected to the receiver low level output, let's call it Channel 1 (CH1) the ring however is a different story, let's call this Channel 2 (CH2). When the switch is down it too connects to the receiver low level output; however, when this switch is switched up it connects the Mic Jack. This allows you to connect low level audio to the right-hand channel or a microphone. If you are recording stereo, you can have the SFERICS or whatever on the left-hand channel and at exactly the same time a comment on the right-hand channel. Let's look at what a comment could be – it could be a microphone listening to a time standard transmitter on short wave say WWV on 10MHz or it could be you speaking into the microphone telling the time of the event that you say from reading a clock.

Electret Microphone Modification

I feel the best thing to use is an old standard PC headset with two 3.5mm jacks – 1 stereo for the headset left and right and the other Mono for the Microphone so “Tip but no ring”. Here is my small upgrade: Using a 1uF Electrolytic capacitor and a 10Kilo Ohm resistor, it is possible to give an electret microphone the supply voltage it needs. The 1uF capacitor blocks DC in the direction of the receiver and the 10K Ohm resistor limits the current to only a few mA for the supply meaning that if you use this jack for anything else other than a microphone, nothing bad will happen if you connect it. This modification is extremely simple and without it unfortunately a boom mic on a headset simply will not work. In the picture, you see how simple this modification is.





Above you see the blue wire has been removed and replaced with the 1uF Electrolytic capacitor, minus side soldered to point 7 on the PCB and plus soldered to the Mic connector tab, where the blue wire was soldered. Now it needs power so at the same point a red wire is soldered which goes to the 10K resistor seen in the right-hand picture, the other end of the resistor is soldered to the top left pin of the main switch so getting power to the electret microphone when turned on, no mic connected no power drain. Make sure the soldering point red wire to resistor does not short with any of the other switch pins, maybe use heat shrink.

Faceplate Labels / Stickers

By placing extra stickers on the faceplate, I cleared up any potential misunderstandings concerning the output configurations. I placed “Headset” labels above the AUDIO POWER switch, above the AUDIO LEVEL knob, and below the middle 3.5mm AUDIO socket. This groups the switchable on off high-power output together nicely. I renamed the DATA LEVEL knob with a “CH1 CH2” label which I think clears up the low-level output grouping quite nicely.

The next sticker concerns the FILTER. The “LPF label below the FILTER switch clearly shows the user it is a Low Pass Filter blocking everything above 100KHz and when switched in, it attenuates unfortunately the wanted signal 6-10dB remember 3dB is by half! The final sticker informs of the input frequency band and its impedance range. Please note here that the BNC connector 50 ohm is used mainly to directly connect only a telescopic antenna with a BNC plug connected directly. In other documents, also available on the INSPRE website that you may also want to read, it is written in depth what happens if you use a 50-ohm coax cable connected here and its interesting reading.

External Battery

Thirty years ago with my old McGreevy self-build VLF receiver I came across the battery problem, namely leaving the battery in risking leaking if forgotten or the damn thing dying in the middle of observations. My solution back then was simple, using 2x small bolts to bolt a battery clip rescued from a dead 9v battery to the case this allowed me every time to simply clip on a fresh battery for every field trip which is a clever solution.

So how do you do this with the INSPIRE VLF receiver? I simply soldered a battery clip to the supplied cable. This allows you to connect your 9V battery externally remember the white stripe + needs soldering to the crown not the stud! This also has the advantage for the dedicated amongst you who perform observations by sub-zero temperatures that you can “BUNG” the battery in your arm put to keep it warm and so provide chemical energy where otherwise the battery would just give up. Yes, thirty years ago teeth chattering at 05:00 in the morning is how I used to do some observing. If you freeze to death, this will sure raise the eyebrows of the pathologist removing it from your stiff and cold body. I wonder if this ever happened if they would measure the voltage ;-) so to say the last observation.

Rubber Feet

I very quickly discovered that INSPIRE VLF receiver could be kicked off the table by my cat who just makes a sport out of booting stuff off the table. So I fitted 4 small rubber feet to the box, this is a very easy and useful modification.

Recording Data

Cassette Recorder or Digital Recorder? Back in the old days 30 years ago the only way to record data was to take a cassette recorder into the field with its very poor batteries, which goofed up in the cold, and a C60 cassette 30 min per side or C120 60 min per side – at least it was stereo. Today the pocket digital recording device is available which is a game changer. They must however have certain features deactivated. First the AGC, or automatic gain control, needs to be deactivated or it will constantly try to amplify nothing then limit if an event takes place. The next function to deactivate is VOX, which is Voice Operated Record. If this is on, you will notice that the elapsed time just stops when nothing is happening. It needs to be constantly recording even when everything is quiet.

How long can you record something with such a device? Let's take the example of 16 Bit CD quality with a typical sample rate of 44.1KHz stereo. If you record for 1 hour, that's 0.635GB; for 24 hours, that's 15.24GB and such a device normally has a 16GB Memory so it will record 1 day's activity nonstop. That is a bit more than with the old cassette 32GB which is also standard and will give you 2 days recording. Now this opens up whole new possibilities. First if you know exactly the start time and know the data rate, it is easy to calculate from the known 0.635GB per hour. Stereo right? Well switch to mono and you get 2 days out of your 16GB recorder – 4 days if you buy a 32GB unit. It is now possible to put everything into a waterproof Tupperware box and to place it out unattended hidden in the field for a few days. Now that's super, super interesting.

With such observational power you should start to think about constant observations, visiting to collect data and fresh batteries every few days. It should be possible to simply change rechargeable batteries but here it should be obvious that the data recorder should use an SD or Micro SD Card instead of onboard SSD only so you can simply change the card. The sky is the limit as much higher sizes of SD may be used up to terabyte sizes. As the INSPIRE VLF receiver can also use 12V supply batteries, the obvious thought here is to use 12V gel lead acid batteries that are also rechargeable. To get power to your digital recorder, select one that can also use 12V or if not, you can step down to the supply voltage needed like 5V with a simple very cheap DCDC converter module. Remember if you start the recorder using your mobile phone which has a very high time accuracy due to its network time technology and you note this time down on a piece of paper, you can record in Mono and you can find the time exactly by looking at the megabyte value of the event. Many audio editing programs let you scroll extremely quickly to events that you can actually see in the spectrogram presentation.

A Transport Case

With remote unattended observations, you might want to purchase a new hard plastic waterproof rugged small suitcase or tool box with a nice chunky handle that may be used to chain it to something with a bicycle type chain.

Wire, Telescopic or Loop Antenna

For E field monitoring, one of my favourite spots was in a park with a bridge over a pond, here I had a long cable with a screwdriver as ground spike connected to it that I simply dropped from the bridge into the water to get an excellent ground connection. Method 2, conductivity is due to wetness and the salts in the ground reducing the resistance. Here having a bottle of salty water to poor on the ground before sticking the screwdriver with a cable into the wet area is an excellent way of getting in the field.

Another field of great interest are H field or magnetic waves, as opposed to electrical field waves. You can observe H fields with so called loop antennas. Many historical inspired loops are simple crosses of wood with many turns of wire wrapped around the tips so forming a square large area loop of wires. This may have been fine in the 1920s for listening to long wave radio but today we can do it much better. I use large polystyrene foam food boxes and wrap wire around them. The dimensions of the box as well as the number of turns is not important as it is not a tuned circuit its job is to cut magnetic field lines and induce signal into the loop. I have good results with 60 to 80 turns of AWG22 plastic coated wire then after the turns are wound, fixing them with silicon glue to the box so they do not vibrate and are damped. With the old 1920s design, the wires moved in the wind so generating electrical noise. Such a box can also be used to keep your receiver and digital recorder dry in the field.

I hope my comments and personal tips are helpful. I now live in Bangkok and it is exciting for me to be able to monitor from this location, which is close to the equator, to make comparisons to my observations conducted decades ago in Germany. For those located mostly in the continents of America, you will find correlation with others in the Florida Keys, Canada or Argentina will be interesting. And remember if politically the world is falling apart, we scientists are above this as science is there for everyone and it brings people together. I was born in 1962 and Neal Armstrong landing on the moon "inspired" me to become an engineer. Thanks NASA. I am currently a guest lecturer teaching electronics at Rajamangala RMUTK University.

A very interesting website for VLF in general: www.vlf.it

PETER WRIGHT UPDATE: SPRING 2024

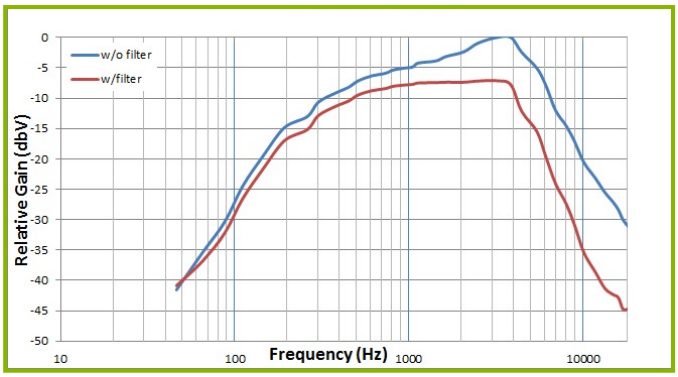
I have been regularly demonstrating the INSPIRE VLF receiver live to Thai people here. I was out on an event where we spent the night watching stars and spotting satellites. I explained in detail how the VLF receiver works. In the morning, we listened to the dawn chorus. As you can see in the picture, our tents were very cleverly elevated to stop snakes from intruding. I bet you have never seen anything like that before – Thai technology

CONGRATULATIONS PETER!

The Team at INSPIRE congratulates Peter and Dada (his wife) on the birth of their son, Arthur, in November 2023.

INSPIRE VLF-3 Receiver Technical Notes

Dennis Gallagher, VLF Receiver Chief Technical Advisor



INSPIRE VLF-3 Receiver Frequency Response Curve

For 35 years, the INSPIRE Very Low Frequency (VLF) 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-3 receiver kit has 114 parts?) 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 15 kHz – an antenna is not included.

VLF Questions from INSPIRE VLF-3 Receiver Users

After setting up the VLF receiver, what software should I use?

I use Spectrum Lab (https://www.qsl.net/dl4yhf/spectra1.html), but there are several packages available, and some operating systems can capture sound. The receiver is sensitive up to about 15 kHz so recording with a sample rate of 48 kHz is plenty. This software can record audio and display it as amplitude as a function of time or as frequency versus time with the amplitude color coded.

I am interested in resources which give some guidance as to how to set up Spectrum Lab to (https://www.qsl.net/dl4yhf/spectra1.html) use with the VLF-3 – I have been trying to get displays similar to the samples on the site but seem to have no success!

If you have hacked around with it and gotten nowhere, perhaps the place to start is to go to "Quick Settings" and next to the bottom select "Restore all factory settings". On the laptop I have it running on right now that took the package to what they call a waterfall spectrum analyzer setup with the laptop microphone as the input audio source. Tapping the laptop or talking should show up as horizontal stripes of color on an otherwise dark blue or purple/black background that scrolls downward vertically with time.

Frequency increases to the right in this display with the frequency axis annotated along the near top of the screen. At the top of the screen is another plot that shows the instantaneous frequency versus amplitude plotted dynamically as amplitude (vertical) versus frequency (horizontal) in a strip plot.

Under "View/Windows" you'll see "Spectrogram" and "spectrum graph" checked. Those are the two types of displays shown on the screen. The spectrogram is the one scrolling downward.

"Help" will take you to the authors user manual. The website for the software has a discussion group. You can select difference other input sources that the computer supports, and you can look at the spectrum of audio files on the computer. There are much more sophisticated things that can be done with the software involving ham rigs that I have not gotten into.

You can customize the software package. There are likely much simpler spectrum analyzer software packages that can be found on the Internet.

If you have not seen a frequency versus time display before, it takes some getting used to. The software is performing a FFT or Fast Fourier Transform on the audio signal to separate sounds of different frequencies for display. Your ears together with your brain does that for you automatically with training at an early age. What you may not have seen is a visual representation. In the "factory setting" setup, you can whistle from the lowest frequency tone to the highest tone and see in the top plot where a peak signal will appear near the bottom of the plot and move to the right. If you wait a little you will see a bright yellow line scroll into view in the spectrogram that sweeps upward and to the right. Both show the single tone you have whistled change in frequency or pitch. Speaking into the computer microphone will show how words have a more complicated frequency or tone content. VLF noise can be simple or complex. Whistlers, originating from lightning, sounds like a descending whistle so it was called a whistler, but it is a naturally occurring electromagnetic radio noise that when simply converted from electromagnetic signal to an acoustic signal can easily be listened to. It can be difficult to use because it can do so many things. Hope this helps!

Special Thanks to Dennis Gallagher, INSPIRE's VLF Chief Technical Advisor
Dr. Dennis Gallagher is a Senior Researcher in the Heliophysics and Planetary Science Branch at NASA Marshall Space Flight Center and serves as INSPIRE's Chief Technical Advisor. Dennis answers VLF kit users' technical questions and mails kit orders! He has been actively involved with the organization since it was founded in 1989.

I put together the VLF-3 unit and it is working great. I was able to put together a video where I have the VLF receiver running in the Spectrum Lab software on my PC and at the same time showing the lightning strikes being picked up by the Lightningmaps website (https://www.lightningmaps.org). There is a time delay in both the Lightningmaps captures and the Spectrum Lab program, but you will see that they weren't too far off. I am located in the southwest corner of Puerto Rico and most of the strikes were from storms near the Island. The video was taken in the morning hours of May 22, 2023. I was wondering if you can have someone who knows about these atmospheric sounds take a look at the video and let me know if they spot anything interesting. Here is the YouTube link: https://youtu.be/p_DI3qtNmoE
– Frankie Lucena, American Geophysical Union, Caribbean TLE Observatory
I finally had the time to watch your video. It is great. It was really nice to match up the VLF with the lightning mapper. You had the opportunity to see when spherics received by the INSPIRE receiver were from nearby lighted versus more distant lightning. I did not notice anything unusual. It reminded me of listening to AM radio and watching thunderstorms when in was young. Dennis

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 submission. All submissions are reviewed prior to publication.

Natural Radio & VLF Group

(Formerly Yahoo VLF Discussion Group)
Visit: https://groups.io/g/VLF

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

The Natural Radio & VLF Group, formerly the Yahoo VLF Discussion Group, was founded by Shawn Korgan in 2001. It is a discussion group dedicated to those who enjoy monitoring radio frequencies in the VLF (very low frequency) radio spectrum (3-30 kHz) and the surrounding radio frequencies. We listen to the amazing Natural Radio sounds created by planet Earth such as whistlers, chorus, tweeks, risers, sferics and hiss on simple VLF receivers (Whistler Receivers). This is a form of radio astronomy. You can listen to beautiful bird-like sounds created by the northern lights on your whistler receiver while watching them at the same time! Or hear an incoming solar flare impact our planet's ionosphere and magnetosphere in real time! Listen to distant lightning's metallic ring during nighttime hours. Study sprites and jets and learn about Space Weather. Discuss VLF receiver designs. Some members monitor Military and Government and VLF stations to assess the effects of solar activity on the ionosphere. Others experiment with transmitting on certain VLF frequencies.

Become a member today by simply sending an email to: VLF+subscribe@groups.io from the e-mail account you wish to have subscribed to the Natural Radio & VLF Group. Membership is open to anyone interested in any aspect of VLF. We encourage new members to visit our website at https://naturalradiolab.com/ for introductory information to the world of Natural Radio listening. *Please note that we conduct our discussions within the bounds of proven science. Discussions of fringe science, speculative science and conspiracy theories are considered off-topic and out of place on this forum.*

INSPIRE VLF-3 Radio Receiver Kit Ordering Information

INSPIRE VLF-3 Radio Receiver Kits can be ordered online at:
www.TheINSPIREProject.org
Discounts are available for non-profit organizations utilizing kits in STEM curriculums.

INSPIRE is currently shipping kit orders domestically but hopes to resume international shipping in 2025.
Orders can take up to 6-weeks to be shipped due to part availability.
All kits are shipped US Priority Mail.

For more information email: CustomerService@TheINSPIREProject.org

Invest Today for the Exploration of Tomorrow

In 2009, The INSPIRE Project expanded its STEM educational programs to provide scholarships and internships to educators, middle/high school students, and university students to ensure the next generation of space science and technology explorers. INSPIRE's team is comprised of dedicated board members and advisors who volunteer his/her time to make it possible for INSPIRE to continue fulfilling its expanded mission of providing students the resources to pursue study in STEM disciplines. If you would like to make a life-changing gift, please visit: www.TheINSPIREProject.org.
Donations are tax-deductible.

For more information about individual and corporate giving opportunities or volunteering, please contact INSPIRE Program Manager:
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Photo: Karin Edgett, 2017 INSPIRE NASA Solar Eclipse Team
Austin Peay State University – Clarksville, TN

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