

EXECUTIVE SUMMARY



From 2016 to 2026, the cross-organizational NESEC team conducted activities in three interconnected areas: GLOBE Observer Citizen Science, Science Investigations with NASA, and Strategic Partnerships.

Earth Observations

- Cloud, eclipse, land cover, mosquito, and tree observations
- Geographic data requests for community and scientist-led projects
- Data tools and curated data sets
- Satellite comparisons for cloud and land cover observations

Online and In-App Resources

- Science background, videos, and tutorials
- Toolkits for informal educators
- Data collection challenges and outreach

Citizen Science with GLOBE Observer

Engage citizen scientists to track changes in the environment in support of Earth system science research and complement NASA and other satellite data.

Science Investigations with NASA

Provide opportunities that align authentic science engagement with NASA STEM, including student research and field campaigns related to NASA science and satellite missions.

Enabling broad participation in authentic NASA STEM by learners throughout their lives.

Strategic Partnerships
Partnerships enable NESEC to deliver NASA STEM to larger audiences. Our collaborators range from large international networks to local community partners, as well as other SciAct Projects.

Research and Experiences

- Student Research Campaigns (Air Quality, GLOBE Mission Mosquito, Trees Around the GLOBE)
- Civil Air Patrol Missions (Solar Eclipse, Aviation Weather)
- NASA GLOBE Clouds
- SEES Earth System Explorers virtual internships
- GLOBE Goes to Camp
- Collaborations with SciStarter, Girl Scouts, and Osher Lifelong Learning Institutes
- ISEF Earth System Science Award

Educator Support

- Webinars and workshops
- Guides for educators and learners

INSTITUTE
for
GLOBAL
ENVIRONMENTAL
STRATEGIES

JPL
Jet Propulsion Laboratory
California Institute of Technology

Goddard
SPACE FLIGHT CENTER

**Langley
Research Center**

200,000+
Learners and Educators

60+
Collaborating
Organizations

304,000+
Citizen Scientists

169,000+
Volunteer Hours

nesecc

BY
THE
NUMBERS



4,000,000+
Photographs Submitted

2,000,000+
Citizen Science Observations

12
Data Request
Projects

1,560,000+
Satellite Comparisons



225+
Subject Matter
Experts

Artificial Intelligence and Citizen Science as a Tool for Global Mosquito Surveillance: Madagascar Case Study

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Abstract
Malaria is a devastating mosquito-transmitted disease that infects over 250 million people and kills more than 600,000 every year. One mosquito of great global concern is *Anopheles stephensi*, an invasive species on the African continent. Unlike native malaria mosquitoes in Africa, this urban-adapted species can breed in artificial containers such as tires and buckets. Early detection of this mosquito is critical for rapid response to prevent increases in malaria; however, traditional surveillance and identification methods may overlook this invasive species. Therefore, we developed artificial intelligence (AI) programs to identify *A. stephensi* using photographed mosquito larvae (similar to the concept of facial recognition), since the most common method for *A. stephensi* surveillance is through the collection of larvae. As a practical proof-of-concept, these tools were used on a photo of a mosquito larva collected from a tire in Madagascar years earlier by local residents, who uploaded this and similar observations to a NASA app. While molecular confirmation is no longer possible on these long-buried larval specimens, the successful use of AI programs to analyze mobile device photo provides a new opportunity to leverage citizen science for larval surveillance, even after the opportunity for physical collection has passed. Ultimately, this study demonstrates the value of integrating AI citizen science in fight mosquito-borne diseases around the world.

Keywords
Anopheles stephensi is an invasive and deadly malaria vector with the ability to use artificial containers as larval habitats. The ability to target for malaria vectors in Africa and require distinct surveillance strategies for early detection and rapid response. In this study, we trained a variety of artificial intelligence (AI) image recognition algorithms, using thousands of example photos of laboratory-maintained (in-captured and semi-endemic) mosquito species, to develop a citizen science-friendly tool for *A. stephensi* larval identification.

Supplemental
Supplemental material for this article is available at <https://doi.org/10.1101/2023.03.15.530000>.

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62 Publications
including 45
Peer-Reviewed Papers

1,000+
Presentations

73
AGU Student
Presentations

Authentic NASA STEM Experiences

The NESEC team excelled at fostering deeper engagement with NASA STEM assets – people, science, and data – across the spectrum of public science engagement. These included large scale events and outreach to millions that increased awareness and inspired interest in NASA STEM, longer-term investigations targeted for educators and learners of all ages, and learner-defined research projects that impacted their science identity and contributed to NASA Science.

Awareness and Inspiration

From outreach events to social media campaigns, the NESEC team brought inspiring NASA science to diverse audiences.

Learning and Experience

NESEC participants learned by doing, whether participating in hands-on activities, citizen science, or research experiences.

Contribution to Science

Participants engaged in every step of the scientific process, from asking questions to collecting data to sharing results.

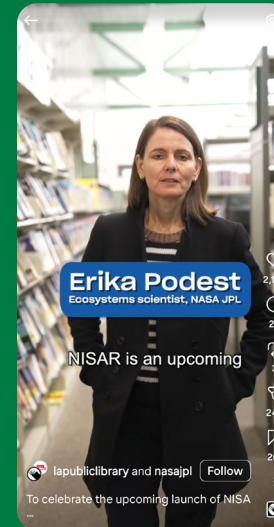
Awareness and Inspiration

NESEC shared NASA science through public outreach and events. The GLOBE Eclipse Challenge: Clouds and Our Solar-Powered Earth from March 15 - April 15 reached 3.5 million people through social media content and videos. Partners engaged thousands through eclipse-related events, including more than 350 library programs reaching over 32,500 participants.

Learning and Experience

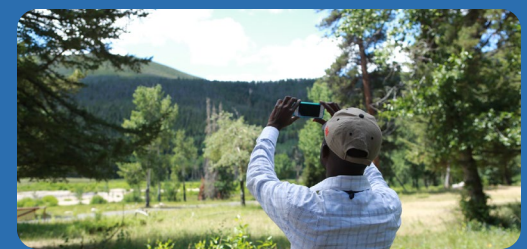
Over 200,000 participants engaged in science investigations using NASA assets, including:

- **Earth System Explorers:** 526 interns and 45 peer mentors completed an 8-week research experience.
- **GLOBE International Virtual Science Symposium:** Over 300 projects were mentored by NESEC team members or participated in NESEC campaigns.
- **Girl Scouts:** 834 troops and an additional 4,899 individual scouts selected GLOBE Observer for their Think Like a Citizen Scientist Journey.
- **International Science and Engineering Fair:** Over 650 students were recognized with the NASA Earth System Science Award.
- **Camps:** Over 70 participating camps and 115,000 campers and their families participated in GLOBE Goes to Camp.
- **Libraries:** Over 400 U.S. public libraries engaged 45,000+ patrons in programs using NESEC resources.



Social Media

NESEC worked with partners to produce social media content, such as this reel from Los Angeles Public Library featuring Dr. Erika Podest answering questions about the upcoming NISAR launch.



Citizen Science

GLOBE Observer enables broader participation in NASA STEM. As of January 2026, there are more than 304,000 registered GLOBE Observers.

Webinars and Workshops: NESEC provided more than 200 webinars, workshops, and tutorials for educators. This professional development prepared them to participate in field campaigns and guide student research using GLOBE and NASA satellite data with online tools.

Subject Matter Experts: More than 225 subject matter experts shared their expertise, reviewed resources for scientific accuracy, mentored students, and used GLOBE Observer data for research and applications.

“Being part of the GLOBE Mission Mosquito Habitat Mapper project is a great way to show our community how they can help scientists discover solutions to help our community.”

Youth Services Librarian
Lee County Library System

“This was one of my top favorite experiences I’ve had with Civil Air Patrol... Not only did we get to partner with NASA on something cool and valuable, but I also learned important skills for my future.”

Cadet Chief Master Sgt. Jacob Buford
Riverside Composite Squadron



Civil Air Patrol

Civil Air Patrol

- **2023 Solar Eclipse Mission:** 1,650 participants
- **2024 Solar Eclipse Mission:** 4,000 participants
- **Solar Eclipse Classroom:** 41,500 K-12 students and 600 educators
- **2025 Aviation Weather Mission:** 3,800 participants

Contribution to Science
62 publications, including:

- 45 peer-reviewed papers
- 10 with student authors or co-authors

“I had only developed skills like coding and AI modeling without any real use for them... I had a lot of fun messing around with real NASA data and playing around with different AI models to try and make something that would actually benefit society, like a program that predicts mosquito density.”

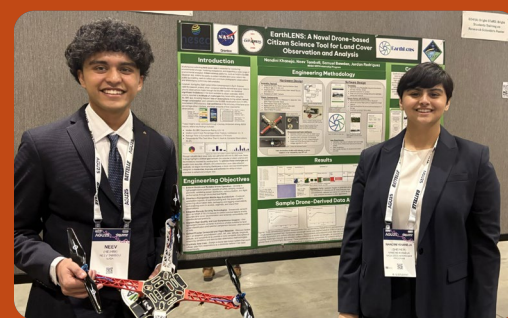
Earth System Explorers Intern

GLOBE Observer Data Requests

This function in the app allows scientists and communities to request observations from GLOBE volunteers in specific locations. The NASA Response Mappers project requested land cover observations in the southern and southeastern U.S. during the 2025 hurricane season. There have been 12 projects to date.



73 Student Team Presentations at the American Geophysical Union Fall Meeting



SEES interns presenting their work on EarthLENS, a drone-based tool combining dual STELLA instruments and AI analysis for enhanced land cover monitoring.

Flexible and Adaptable STEM Resources

NESEC developed and disseminated resources based on NASA STEM that field testing and evaluation shows are highly valued by our partners and collaborators. These resources have been used and adapted by a wide range of partners for audiences including camps, classrooms, libraries, parks, scouts, and families.



NUBE Card Game

Co-developed with Queens Public Library, this simple card game is designed to help players learn the different cloud types. Decks were distributed to over 300 libraries through NASA@ My Library.

"The young people that came for our NUBE drop-in game night were not particularly knowledgeable about clouds but showed a good proficiency after a couple rounds. The players became so excited about playing the game that their reactions could be heard across the library."

NUBE Game Evaluation Survey

Color-a-Pixel

This activity allows educators to turn any satellite image into a color-by-numbers activity. The Earth to Sky team uses the activity to connect NASA Earth and space science to visitor experiences at parks, refuges, and nature centers.

"This low-tech activity is powerful because of its simplicity. All you have to do is pick up a crayon, follow the easy number guides, and discover the stories that NASA satellites are telling us about our world and beyond."

Brandi Stewart Earth to Sky



Library Kits

Several libraries have developed science kits that patrons can borrow. Los Angeles Public Library worked with NESEC to create GLOBE Observer kits focused on clouds, mosquitoes, and urban heat island/trees. The kits are available at 35 different branches.

"We created a Storm Chaser Kit that contains the NUBE game along with books on weather and weather related tools that can be used intergenerationally."

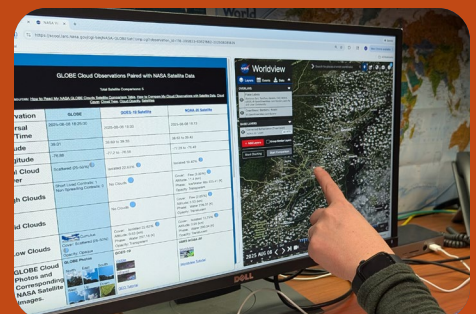
Falmouth Public Library
Massachusetts

Satellite Comparisons

GLOBE Observer participants who opt-in receive an email comparing their Clouds and Land Cover observations to satellite data. These emails have been reported to motivate volunteers and help them see how their observations fit in the larger space-based view.

"I forwarded the NASA satellite response to the after-school coordinator, and she read it to [the students]. That really excited them because it was evidence this is the real deal."

Children's Programming Librarian LaGrange, KY



Resource Collections

In addition to creating flexible materials, the NESEC team remixed these resources by curating collections for different audiences.



Toolkit for Informal Educators

This collection of resources was developed to help informal educators, such as librarians, park rangers, and camp counselors, incorporate GLOBE Observer into their programming. For each tool in the app, there are:

- Hands-on activities
- Videos and presentations
- Printable materials
- Book lists for kids and adults
- Tips for using the app
- Guides for specific audiences

Audience Guides

In addition to general resources for informal educators, the NESEC team worked with specific audiences to develop guides for their settings, including Girl Scouts, 4-H, Camps, and Libraries.

GLOBE Goes to Camp

The GLOBE Goes to Camp project worked with camp counselors across the U.S. to design, test, and revise camp programming around collecting data with GLOBE Observer. Partners implemented the activities, provided feedback, and met regularly to provide peer support. The camp guide was developed based on this feedback.



Activity Trackers

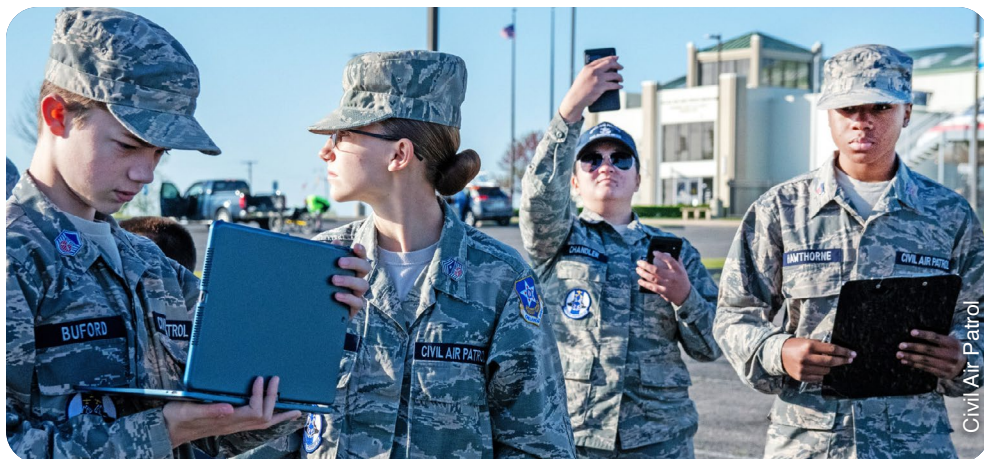
When COVID-19 shut down schools, libraries, and museums, the NESEC team found ways to engage learners at home. Activity trackers offered a way to curate activities around different themes and provide options for participants even if they couldn't go outside to collect observations. Our partners with Los Angeles Public Library translated these materials into many languages, including Armenian, Chinese, Japanese, Korean, Persian, Russian, and Spanish.

NASA Resource Collections

À la carte resources have been incorporated into broader NASA collections, including NASA at Home, Earth Day Toolkits, and the Moon Trees STEM Toolkit.



High Impact Partnerships and Collaborations

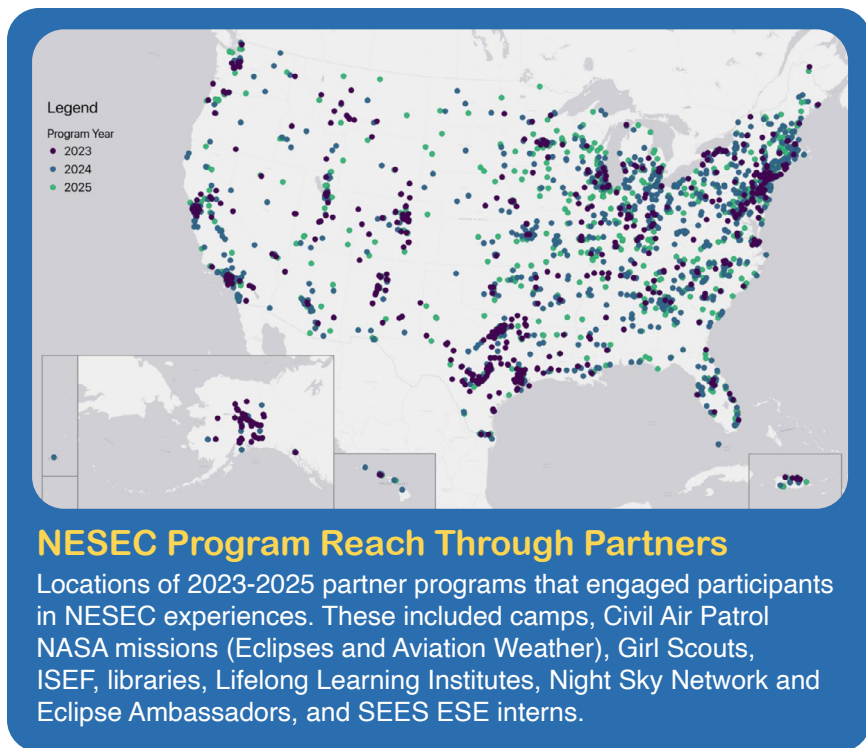


60+ Collaborating Organizations

Participation in all **50 U.S. states** +DC, Puerto Rico, and the U.S. Virgin Islands and **105+ countries.**

NESEC has fostered unique models of high-impact partnerships working with wide-ranging groups including Civil Air Patrol, libraries, camps, master naturalists, and lifelong learners. Our team has also had successful cross-collaborations with more than 20 NASA SciAct teams.

Partners are disseminating and promoting our offerings, co-presenting at conferences, adapting NESEC resources for their audiences, co-developing resources, and implementing programs. Annual partner surveys report that NESEC is meeting our partners' needs and these partnerships are mutually beneficial and valued.



NESEC Program Reach Through Partners

Locations of 2023-2025 partner programs that engaged participants in NESEC experiences. These included camps, Civil Air Patrol NASA missions (Eclipses and Aviation Weather), Girl Scouts, ISEF, libraries, Lifelong Learning Institutes, Night Sky Network and Eclipse Ambassadors, and SEES ESE interns.

“Using the app in our programming has allowed our patrons to see that there are possibilities outside our area that many may have never thought of before. We are also able to show that living in our area of rural Northwest Tennessee can still mean doing valuable things in and for the world.”

Leveraging our complementary assets and skills with partners has greatly expanded our reach and engaged more diverse participation - particularly in rural areas. Partners provided local support and community for participants, and connected NASA STEM to topics of local interest and context. Our team provided professional development, educational resources to support partner programs, and ongoing support that is responsive to partner needs and questions.