Universities Space Research Association

2023 Annual Report

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MISSION

Advance the space- and aeronautics-related sciences exploration through innovative research, technology, and education programs

Promote space and aeronautics policy

Develop and operate premier facilities and programs by involving universities, governments and the private sector for the benefit of humanity

VALUES

Passion—for science, technology, and education

Partnerships—with universities, governments, and the private sector

Professionalism—through excellence, accountability, and respect for others

Cover Image: The OSIRIS-REx journey to and from Bennu. Image Courtesy: NASA Goddard Space Flight Center

Message from the President and Chief Executive Officer and the Chair of the Board of Trustees

Jeffrey A. Isaacson,
President and Chief
Executive Officer, USRA

Gen. Lester A. Lyles
(ret.),
Chair, Board of
Trustees

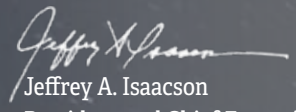
2023 brought many important developments to USRA, including the election to membership of the Association's first South Asian university—the Indian Institute of Space Science and Technology (IIST). IIST became USRA's 117th member within its Council of Institutions (COI).

In addition, USRA's COI enacted a pivotal change to USRA's Bylaws enabling the creation of Science and Technology Working Groups, designed to facilitate collaboration among USRA and universities having expertise in technical topics of particular interest. These Working Groups are intended to serve as a resource to USRA, universities, and government agencies by providing guidance on emerging trends, funding opportunities, and technology development. Following this change, USRA established its first Working Group, focused on space nuclear technology development and space exploration, and consisting of faculty from six leading universities nationwide.

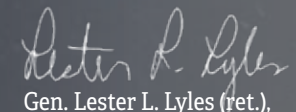
Through the hard work and dedication of its capable staff, USRA achieved many other noteworthy accomplishments in 2023. Among these:

- USRA staff published 187 peer-reviewed research products and, across all programs, executed a total of 1004 research engagements with 343 organizations, including a 29% increase in research engagements with Minority-Serving Institutions.
- USRA collaborated to validate the discovery of 69 new exoplanets using a deep neural network called ExoMiner, and developed a new topographic map of Enceladus that showed Saturn's icy moon is being deformed by internal processes well outside the areas of active venting at the South Pole.
- With USRA support, the low-gravity science program at NASA's Glenn Research Center continues to develop and operate instruments and experiments for the International Space Station (ISS) National Laboratory, including a NASA-awarded experiment for successful long-term operations of a Light Microscopy Module on the ISS.
- USRA administered or supported 592 interns, including 391 Air Force Research Laboratory (AFRL) Scholars, and received $8.8M of funding for the second cycle of the AFRL/USSF University Consortium Research Opportunity.
- USRA's Earth from Space Institute (EfSI) provided several key scientific visualization developments for the new NASA Earth Information System, which is displayed at NASA's Headquarters in Washington, DC.
- A delegation from USRA attended the 2023 United Nations Climate Change Conference (COP28), held in Dubai, United Arab Emirates. The Conference of Parties (COP) is the decision-making body responsible for implementing the global climate convention, known as the United Nations Framework Convention on Climate Change (UNFCC). At COP28, USRA co-hosted a panel session titled, Earth Observations in Support of Mitigation Actions Towards the Paris Climate Goal and Sustainable Development Goals, partnered with the National Institute of Environmental Studies, Japan.
- After a full and open competition, NASA awarded USRA a new cooperative agreement titled, Support for Planetary Sample Science (SPSS), which is the follow-on to the existing agreement for USRA's Lunar and Planetary Institute (LPI). With this award, USRA continues a long-standing role supporting NASA's Planetary Science Division and Johnson Space Center, which dates to USRA's founding in 1969.
- USRA established a new research relationship with the Under Secretary for Science and Technology, Department of Homeland Security (DHS). The program is focused on enabling innovation in emerging technologies of special interest to DHS, including artificial intelligence, quantum information science, and autonomy.
- USRA was selected as one of five organizations chosen by the Department of Energy's Advanced Research Projects Agency—Energy to develop new pioneering technologies and tools aimed at reducing the environmental impact of aviation.

These highlights, and those that follow, summarize USRA's 2023 accomplishments in furthering its mission to advance space- and aeronautics-related sciences and exploration; promote space and aeronautics policy; and operate premier facilities and programs involving universities, governments, and the private sector. Of course, these highlights can't capture everything, but we do hope they convey the passion we hold for science, technology, and education that has driven our mission success since 1969.



Jeffrey A. Isaacson
President and Chief Executive Officer



Gen. Lester L. Lyles (ret.),
Chair, USRA Board of Trustees

Aeronautics Research and Development

USRA's mission is to advance aeronautics technologies for the benefit of humanity.

Unmanned Aircraft Systems

USRA maintains an ongoing partnership with NASA's Ames Research Center in the development and enhancement of Unmanned Aircraft Systems (UAS). This collaboration extends the capabilities of the acclaimed UAS Traffic Management (UTM) system and various software tools. The overarching objective is to facilitate a comprehensive understanding of the operational landscape and enhance the effectiveness of coordinated decision-making processes.

Furthermore, joint efforts are underway to conduct flight experiments, particularly focusing on disaster preparedness, response, and recovery scenarios. These endeavors are conducted in conjunction with a diverse array of collaborators, spanning academia, industry, and government entities.

Artist's rendering of unmanned aircraft. Image Courtesy: Forge Branding.

Sustainable and Safe Airspace Operations

The engineers at USRA's NASA Academic Mission Services (NAMS) team work in collaboration with NASA's Ames Research Center, small business partners, universities, and various organizations to advance Next Generation Air Transportation System technologies. Their mission is to streamline air travel, minimize delays, enhance safety under all weather conditions, and mitigate aviation's environmental footprint. This initiative aligns with the objectives set forth by the U.S. Federal Aviation Administration (FAA).

During the past year, USRA's NAMS program supported NASA's Ames Research Center to develop a Digital Information Platform (DIP) and conduct sustainable aviation demonstrations with conventional airline flight operators, and to measure reductions in fuel use and emissions through improved air traffic decision making using a digital ecosystem including use of machine learning models. This builds upon prior research with the Airspace Technology Demonstration 2 (ATD-2) project which resulted in the FAA Administrator announcing that the Integrated Arrival/Departure/Surface technology, developed as part of the NASA Airspace Technology Demonstration (ATD) project, will be integrated with FAA systems and deployed for production use at 27 hub airports over the next decade. This followed the completion of the ATD project after nearly four years of demonstrated use at the Charlotte Douglas International Airport by American Airlines and the FAA, which demonstrated significant reductions in delays on taxiways and runways, use of aviation fuel, and aircraft emissions.

Air Mobility Pathfinders

The NASA Academic Mission Services team is supporting NASA's Air Mobility Pathfinders (AMP) project to accelerate the realization of safe and scalable Advanced Air Mobility (AAM) capabilities through the development of transformative airspace-operations technologies and through integrated demonstrations of candidate operational concepts and scenarios.

This effort involves collaboration with the growing industry that is producing advanced air vehicles, including electric Vertical Takeoff and Landing aircraft, high-altitude long endurance aircraft, and autonomous drones. The work also supports various missions including transporting people and cargo between places previously underserved by aviation and for remote sensing for disaster preparedness, response, and recovery.

This past year, the NAMS team collaborated with NASA's Ames Research Center to conduct National Campaign 1 (NC-1) activities with four separate industry partners. One of the partners, a cohort of 15 government, industry, and academic entities led by the University of North Texas, completed a live flight test in the North Texas area with the goal of collecting vital data and lessons learned for developing industry standards in airspace management, vehicle-to-infrastructure communications, and autonomous flight operations.

Bell Textron 407GXi helicopter in flight during an AAM NC-1 flight demonstration in North Texas. Image Courtesy: University of North Texas.

Digital Information Platform

USRA engineers on the NAMS team collaborate with NASA's Ames Research Center to develop a Digital Information Platform (DIP) . This is designed to facilitate advanced, data-driven, digital services for flight operators aimed at enhancing efficient aviation operations in all airspaces. These services encompass high-altitude autonomous vehicle operations including passenger and cargo transport. This collaboration builds upon the success of the ATD projects and the latest in cloud-based infrastructures and artificial intelligence technologies.

In doing so, this effort realizes the FAA and NASA vision for the digital transformation of Air Traffic Management from trajectory-based approach to a more collaborative and highly automated framework.

In 2023, the DIP team deployed a real-time machine learning-based decision support system in the cloud as part of a field evaluation of the Collaborative Digital Departure Rerouting (CDDR) technology. The CDDR demonstration was conducted with two airline partners at the Dallas/Fort Worth international Airport and Dallas Love Field Airport. Results confirmed there provide a viable path for the use of machine learning digital services that maintain or improve current system performance compared with the legacy decision support tool. The CDDR demonstration is expanding to the Houston, Texas, area in collaboration with the FAA and with multiple airlines operating in the region.

Low Gravity Sciences

As members of NASA's Glenn Research Center microgravity science team, USRA scientists support the goals of the Science Mission Directorate's Biological and Physical Sciences (BPS) Division through the use of the International Space Station (ISS) as an experimental platform to understand the physical effects of microgravity on physical and biological systems. These investigations into how these systems respond to the effects of reduced gravity and radiation may someday lead to new discoveries that might reduce risks of prolonged space exploration and eventually benefit life on Earth.

Revolutionizing Crystal Production in Space:

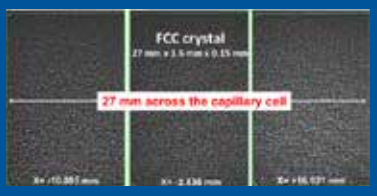
Unveiling the Potential of Colloidal Photonic Crystals

The Universities Space Research Association was awarded a flight opportunity on the International Space Station National Laboratory (ISSNL) to pursue groundbreaking results through flight experiments on the ISSNL. Earlier experiments, known as the Advanced Colloids Experiment (ACE)-T11 and ACE-TR, unveiled a significant breakthrough: the ability to create defect-free 3D crystals with colloidal particles in long-duration microgravity and successfully return them to Earth. This achievement opens the door to new possibilities for in-space commercial production of colloidal photonic crystals in Low Earth Orbit (LEO).

These experiments have laid the foundation for USRA's proposed work, which is geared towards developing the necessary technical guidance for scaling up on-orbit crystal growth capability. By carefully analyzing the effects of changing specific parameters on colloidal growth and structure, approximately 100 samples with different combinations of container shapes, colloidal particles, and fluids will be selected and ranked. This step is a crucial precursor to expanding the production of photonic crystals in space.

The impact of this research extends far beyond scientific curiosity. By overcoming the limitations of gravity on Earth, this technology can create photonic crystals with many practical applications in telecommunications and computing. The proposed flight experiment holds the potential to reshape our daily lives by enabling faster and more efficient technological innovations. Partners in the upcoming ISSNL research include New York University, New Jersey Institute of Technology, and Nanoracks, LLC.

Background Image: A view of NASA astronaut Jessica Meir configuring the Light Microscopy Module for the Advanced Colloids Experiment-Temperature-4 (ACE-T-4) in the Destiny module aboard the ISS. Image Courtesy: NASA.



Images of the Face Centered Cubic (FCC) crystal that survived re-entry from the International Space Station. Image courtesy: NASA.

SPARC Ohio: Leading Economic Growth through Space Innovations

The Science Park Accelerator & Regional Catalyst – Ohio (SPARC Ohio) is a pioneering initiative led by the Universities Space Research Association. Its primary goal is to position Ohio as a key player in the projected $1 trillion space economy, fostering advancements in space research and development (R&D) and manufacturing for the betterment of life on Earth. Leveraging Ohio's strengths in space, biological, and physical sciences, SPARC Ohio aims to promote inclusive education, job creation, and U.S. leadership in the commercial space sector.

Through the incorporation of cutting-edge space technologies, SPARC Ohio is anticipated to generate groundbreaking innovations. These innovations include the development of highly durable, lightweight, and energy-efficient products with the potential to revolutionize life on our planet. The initiative takes advantage of the unique research and manufacturing environment in space, harnessing the transformative potential of microgravity for experiments and manufacturing processes that are not feasible on Earth.

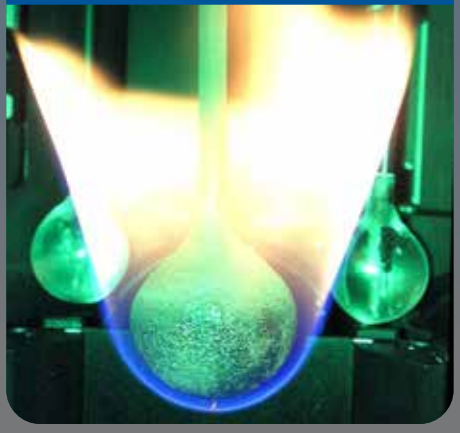
Positioning itself as a pioneering space technology hub, SPARC Ohio will serve as a platform for innovative ideas, fostering collaborations among scientists, industry experts, and academic minds. By prioritizing use-inspired, impactful research, USRA ensures that SPARC Ohio contributes to advances in semiconductors, consumer products, healthcare, food production, and environmental sustainability.

The success of SPARC Ohio is greatly attributed to the collaborative efforts of various partner organizations, including Case Western Reserve University, NASA Glenn Research Center, the Manufacturing Advocacy and Growth Network (MAGNET), the Ohio Aerospace Institute, and many other valuable partners. This collaborative approach underscores a shared commitment to revolutionize space research, manufacturing, and education, solidifying Ohio's status as a premier destination for groundbreaking space science endeavors.

Solid Fuel Combustion in Microgravity

Growth and Extinction Limits Experiment Milestone Achieved

A 4-centimeter diameter acrylic sphere undergoing combustion in a microgravity environment. Image Courtesy: NASA Glenn Research Center.



The Universities Space Research Association plays a crucial role in the Solid Fuel Ignition and Extinction (SoFIE) project, specifically the Growth and Extinction Limits (GEL) experiment. GEL recently achieved a significant milestone by completing the first phase of its testing. This experiment is part of a series of five investigations that utilize the SoFIE chamber within the Combustion Integrated Rack.

Currently, GEL is focused on mapping the flammability limits of a 4-centimeter spherical acrylic fuel in the unique microgravity environment of the International Space Station. Operating at around 21 percent oxygen and 1 atmosphere (the normal standard everyday pressure experienced on earth at sea level), GEL's goal is to determine how different conditions affect the fuel's combustion. Oxygen is replenished within the Combustion Integrated Rack's chamber to maintain a consistent atmosphere during combustion.

A notable aspect of this experiment is that the combustion limits are influenced by the burning history and internal preheating of the solid fuel. To explore these dynamics, multiple burns were conducted under various parameter variations. The funding for this groundbreaking work comes from NASA's Biological and Physical Sciences division.

Lunar and Planetary Science

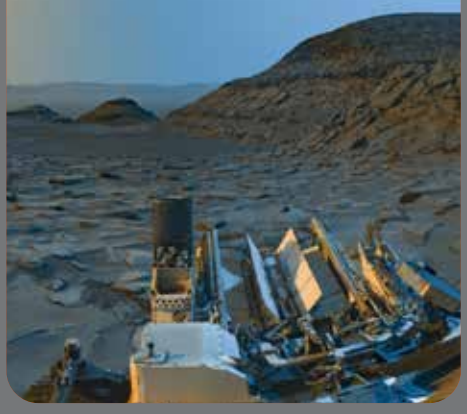
Research conducted by USRA scientists helps to advance our understanding of the solar system from its formation through its evolution to its current state.

Artist's concept of the Mars Curiosity rover firing a laser via ChemCam for LIBS analysis. USRA Scientist Laura Rodriguez is working with the ChemCam team to develop strategies to search for organic matter using this technique. Image Courtesy: NASA/JPL-Caltech.

Investigating the Chemical Building Blocks of Life on Mars

Over the last decade, NASA's Mars Science Laboratory's Curiosity rover has been exploring the martian surface at Gale Crater, a large impact basin with a massive, layered mountain in the middle. Evidence suggests that Gale Crater, which formed via an impact event approximately 3.7 billion years ago, was later infilled by water, forming a lake and conditions that may have been habitable for martian life. USRA's Dr. Laura Rodriguez of the Lunar and Planetary Institute has been working closely with scientists who operate the ChemCam instrument on Curiosity. As the Science Payload Uplink Lead (SPUL), Rodriguez selects targets for Laser Induced Breakdown Spectroscopy (LIBS), reflectance spectroscopy, and remote micro-imaging of local geological features. Theoretically, the LIBS instrument can facilitate the search for martian life by detecting all the biogenic elements—carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur (CHNOPS)—from samples up to 7 meters away. Rodriguez is developing strategies to detect these elements using ChemCam and to find organically-rich targets that help inform mission operations.

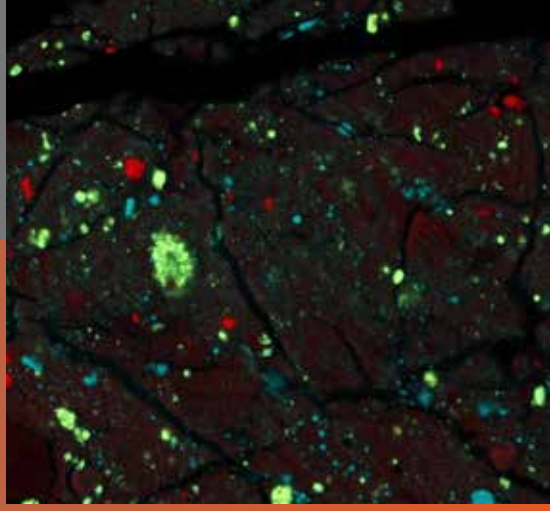
An artificially colorized morning view of "Marker Band Valley on Mars" taken by Curiosity's navigation cameras. Image Courtesy: NASA/JPL-Caltech.



Returned Samples from Asteroid Ryugu Are Time Capsules of the Solar System

Samples returned from the near-Earth, carbonaceous (C-type) asteroid 162173 Ryugu, collected by JAXA's Hayabusa2 spacecraft, are producing new insights into the earliest evolution of our solar system. The focus of ongoing analyses is to identify tiny mineral grains that may be remnants of the first solids formed in our solar system and determine their textural and chemical properties.

One of the most exciting discoveries from Ryugu is that the samples contain "less-altered" areas, which have dry silicate minerals (olivine and pyroxene) and Ca-Al-rich minerals that may be remnants of primordial chondritic (CI) materials. Scientists at the Lunar and Planetary Institute and partner institutions have found that these diverse materials point toward multiple nebular reservoirs for the materials that accreted to form CI-type planetesimals more than 4.56 billion years ago.



False-color image of a Ryugu sample, made from combined X-ray maps for the elements magnesium, iron, and sulfur. Bright red grains are olivine, unaltered remnants of the most primitive solar system solids. These tiny mineral fragments can be studied by electron microprobe analysis, transmission electron microscopy, and NanoSIMS, to reveal the chemical and isotopic properties and nebular sources of primordial solar system materials. Image Courtesy: C. Goodrich/USRA/LPI

The mountainous Ishtar Terra region of Venus formed during a time when Venus had a mobile surface geology similar to present-day plate tectonics on Earth. Image based on NASA Magellan mission data. Image Courtesy: NASA.

Venus Atmosphere Potentially a Consequence of Early Plate Tectonics

Of all the first-order questions about the evolution of Venus, perhaps the most significant centers on the apparent divergence between the sibling terrestrial planets of Venus and Earth. While we know the tectonic and atmospheric states of Earth, the evolution of Venus is largely unconstrained. At present, Venus' surface shows no clear evidence of Earth-like plate tectonic activity, but its early evolution remains a mystery. Venus is shrouded by a thick atmosphere resulting in an extreme greenhouse climate with surface temperatures exceeding 800 degrees Fahrenheit. A planet's atmosphere is fundamentally linked to its interior through melting and outgassing. As a result, Venus' atmosphere offers important constraints on the planet's tectonic evolution.

Researchers at the LPI compared the current venusian atmosphere with atmospheres generated by numerical experiments of long-term thermal-chemical-tectonic evolution. Their findings indicate that Venus' atmosphere is the result of a great tectonic-climatic transition, from an early phase of plate-tectonic-like activity that lasted for at least one billion years followed by the current period of reduced outgassing rates, called a "stagnant lid" mode. This result indicates that Venus-type atmospheres are potentially a consequence of early phases of plate tectonics.

Earth Science

USRA scientists strive to understand the Earth's natural processes, their propensity to change, and the linkages between human and natural systems. They also work across sectors and disciplines to apply Earth Observations for broad societal benefit.

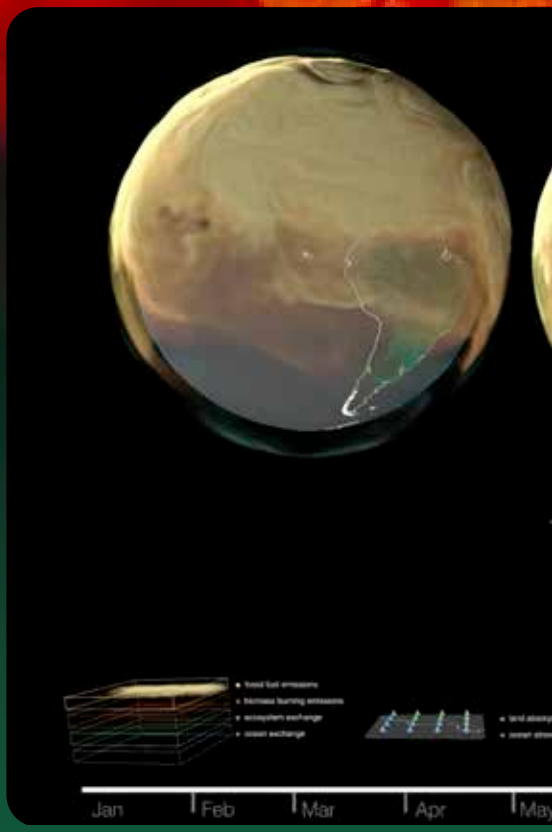
Helen-Nicole Kostis in front of the Greenhouse Gases Dashboard, Hyperwall Display, NASA Earth Information Center. Image Courtesy: NASA Earth Information Center; Photo: Brenda Lopez Silva.

High-Impact Data Visualizations for NASA's Earth Information Center

NASA Administrator Bill Nelson led the ribbon cutting ceremony of the Earth Information Center (EIC) at NASA Headquarters in Washington, D.C. The EIC includes a public-facing exhibit that showcases our planet's changing climate with near-real time and awe-inspiring data visualizations and dashboards.

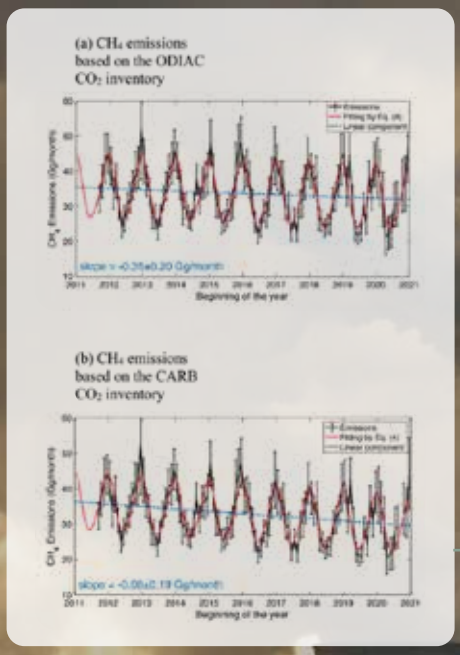
The exhibit includes a 22-feet wide LED hyperwall framed by two circular 4K screens. Helen-Nicole Kostis, senior data visualization developer at the Scientific Visualization Studio (USRA/EfSI) led the design, production and development of EIC's 22 feet hyperwall dashboards and visualizations. The hyperwall's data visualizations at NASA's EIC reflect earth science at its best, by combining scientific models, satellite observations and ground measurements from teams across the agency. The hyperwall features the latest data available, with the goal of making scientific data accessible to people. One of the requirements for realizing this effort was the development of new types of visualizations paired with new pipelines. Team member Kelly Elkins (USRA/EfSI) spearheaded the new pipelines for the EIC and Trent Schindler (USRA/EfSI) developed visualizations according to these new pipelines.

The EIC is open to visitors from 8:30 a.m. to 5:30 p.m. Monday through Friday at NASA's Headquarters, East Lobby.



ODIAC Emission Continues Contributing the GHG Monitoring

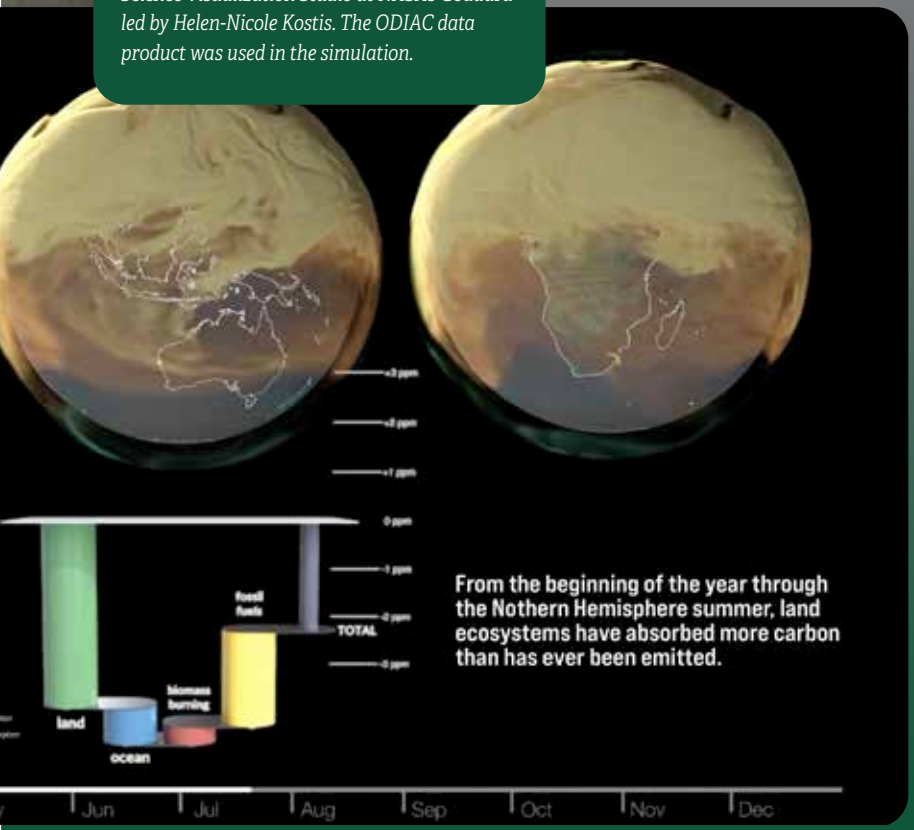
USRA's Dr. Tomohiro Oda has been maintaining the global high- resolution open source data inventory for anthropogenic CO_2 (ODIAC) simulations for studying the optimal observation strategies, evaluating remote sensing retrieval data collected by the missions and maturing the use of the data for emission evaluations in collaboration with USRA's federal and university partners. The ODIAC emission data product is considered to be a key input for the U.S. Greenhouse Gas Center (GHC) and the new Global Greenhouse Gas Watch (G3W) initiative run by the World Meteorological Organization (WMO). Oda and his external collaborators developed a method to quantify GHG emissions using a wide variety of earth observation remote sensing data in response to the need for climate mitigation monitoring at local scales. A study led by the Caltech and JPL colleagues used the ODIAC data and the ground-based remote sensing data to show the reported CH4 emissions reduction was overestimated. The study appeared in *Nature Communications.*



Decadal decreasing trend of CH4 emissions. Image Courtesy: Nature Communications, 2023. Zeng et al, with permission, under license from Creative Commons http://creativecommons.org/ licenses/by/4.0.

Greenhouse Gas Sciences for Climate Science and Mitigation at EfSI

Atmospheric CO_2 simulation visual done by the Science Visualization Studio at NASA's Goddard led by Helen-Nicole Kostis. The ODIAC data product was used in the simulation.



Dr. Tomohiro Oda, a senior scientist at USRA's Earth from Space Institute, continues to support carbon observing missions/programs by our domestic and international sponsors, such as NASA, the Japan Aerospace Exploration Agency (JAXA), and the European Space Agency (ESA), including NASA's Carbon Monitoring System (CMS), the Earth Information System (EIS), the Orbiting Carbon Observatory (OCO)-2/3 mission, the French-UK Microcarb mission, Japan's Greenhouse gas Observing SATellite (GOSAT) mission and JAXA's Greenhouse gas Observations of Biospheric and Local Emissions from the Upper sky (GOBLEU) airborne remote sensing mission. Oda and his team also contribute to the newly established U.S. Greenhouse Gas Center (which was announced by the White House this past summer) and led by NASA in collaboration with U.S. agencies.

The NASA Science Visualization Studio led by Helen-Nicole Kostis, senior scientist at EfSI, continues supporting the science visualization products from NASA, which have been presented at NASA's Earth Information Center (EIC) and numerous NASA hyperwall presentations including ones at the U.S. Center at the COP27 climate conference in Egypt.

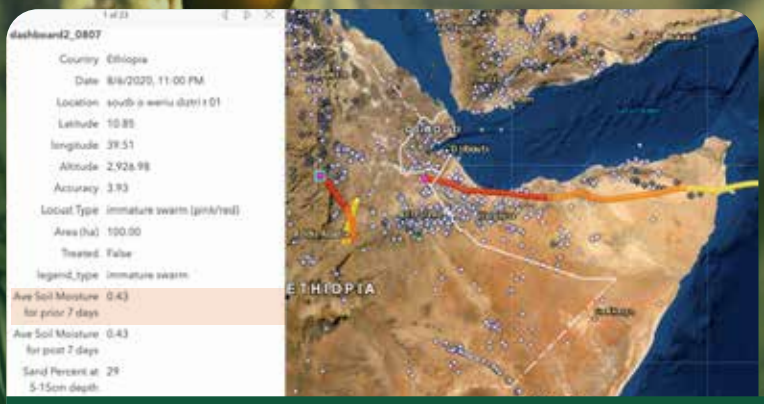
Earth Science *Continued*

Protecting Crops from Locusts in Africa and Asia

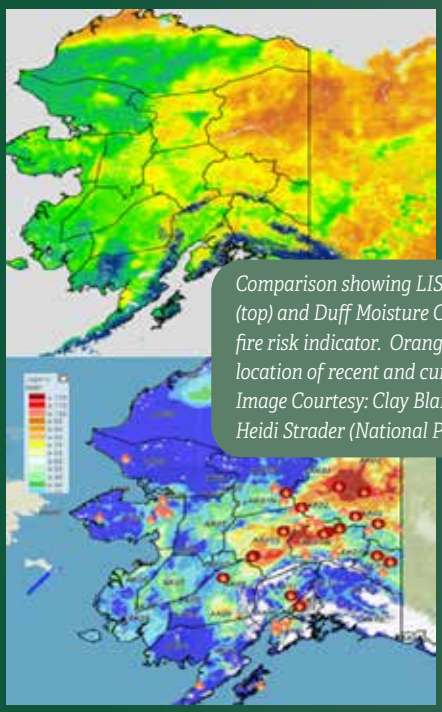
Locusts are a major threat to crops in Africa and Southwest Asia, causing billions of dollars of losses. Identifying areas with ideal conditions for locust breeding (sandy soils and a certain soil moisture range) is critical for mitigation efforts. Land surface models (LSMs) can be used to simulate the soil moisture based on satellite rainfall observations and other factors such as temperature and solar radiation.

Dr. Clay Blankenship, at USRA Science and Technology Institute, manages a Noah LSM run within the NASA Land Information System over Africa for NASA SERVIR, which provides satellite and model data and capacity building to international partners. The ~3-km resolution model run includes a real-time component forced by satellite and conventional observations, and a 15-day forecast driven by the the NOAA Global Forecast System (GFS) weather model.

The model soil moisture is used to monitor current and forecast soil conditions by the U.N. Food and Agriculture Organization (FAO). Local authorities use this information to manage and fight potential locust outbreaks, which can cause significant and catastrophic crop loss.



Swarm Trajectory Prediction Simulation Results. Locust analysis conducted by Plantvillage at Penn State in collaboration with UNFAO partners. The image is a screen shot from the Plantvillage website showing use of LIS moisture output. Image Courtesy : Plantvillage website with permission from https://creativecommons.org/licenses/by-sa/3.0/deed.en.



Comparison showing LIS soil moisture output (top) and Duff Moisture Code (bottom), another fire risk indicator. Orange/red fire icons indicate location of recent and currently active wildfires. Image Courtesy: Clay Blankenship (USRA) and Heidi Strader (National Park Service).

Helping Prevention of Natural Hazards in Alaska

In Alaska's sparsely populated areas, information on soil moisture and snowpack is needed for flood and wildfire risk, streamflow prediction, and other applications. Land surface modeling can be used to provide data at high spatial and temporal resolution.

Dr. Clay Blankenship of USRA STI manages a Noah land surface model run over Alaska using the Land Information System (LIS) for the NASA Short-Term Prediction Research and Transition (SPoRT) Center. The ~3-km resolution model is driven by Global Data Assimilation System forcing data incorporating remotely sensed and conventional observations.

The Alaska Fire Service has incorporated LIS output into their display system and decision-making tools. Soil moisture is an indicator of vegetation moisture and therefore a fire risk. The Fire Service also uses the snow maps to initialize fire weather indices for a given location on the first snow-free day. Model output is also available at the Alaska-Pacific River Forecast Center and the three Weather Forecast Offices in Alaska, giving forecasters awareness of soil conditions that can exacerbate flooding or landslides.

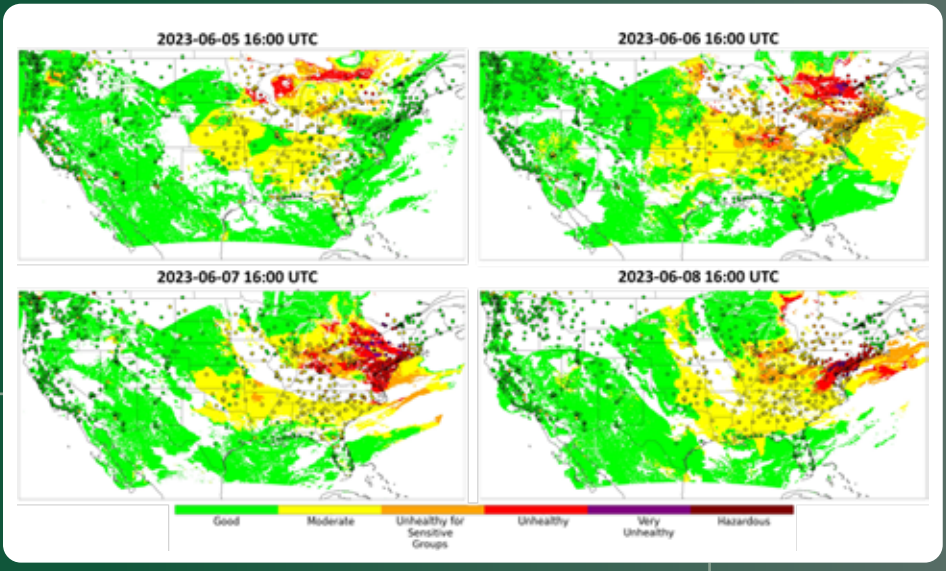
Engaging Citizen Scientists and Low-cost Sensors for Better Air-Quality Monitoring

Addressing the critical environmental justice issue requires a multidisciplinary approach that encompasses environmental science, public health, clinical medicine, and citizens' engagement, all aiming to safeguard the well-being of populations worldwide.

In this effort, we are providing low-cost sensors from Purple Air, (PA) to citizen scientists to increase the network of ground measurements. We are also providing training materials to citizen scientists to operate the instrument and automate the data upload process. The deployed PA sensors are then calibrated using machine learning with U.S.-EPA's regulatory grade monitors (RGM's). In the second phase of this project, we are using calibrated PA sensor data to estimate $PM_{2.5}$ using aerosol optical depth derived from remote sensing data of geostationary satellites (GOES-R series).

This initiative is significant as it addresses critical environmental justice issues by involving citizens in monitoring air quality, which can lead to more informed decision-making and policies to protect public health. Additionally, the use of low-cost sensors and remote sensing data highlights the potential for cost-effective and scalable solutions to tackle air pollution challenges across the country.

Estimating High-Resolution $PM_{2.5}$ Leveraging Geostationary Satellites, Numerical Models, and Deep Neural Networks



A map showing GOES (East and West combined) $PM_{2.5}$ from June 5-8, 2023, over the continental U.S., colored by the US EPA AQI. The progression of unhealthy concentrations of $PM_{2.5}$ in the southeastern U.S. was due to recent Canadian wildfire episodes. The colored dots represent the ground measurement from EPA's AirNow network while the shades colors are ML-estimated $PM_{2.5}$. Image Courtesy: USRA.

$PM_{2.5}$, as a complex mixture of fine particulate matter, encompasses a range of constituents, including polycyclic aromatic hydrocarbons (PAHs), black carbon (BC), organic matter (OM), and other components. While respiratory and cardiovascular health effects vary depending on exposure duration and components, there is a growing body of evidence linking $PM_{2.5}$ exposure to adverse health outcomes. There is a need to emphasize ongoing research efforts, pollution control measures, and the development of clinical guidelines to mitigate the adverse health effects of $PM_{2.5}$ exposure.

Our research focuses on amalgamating various data sources including ground measurements, satellite remote sensing, and numerical models using state-of-the-art machine learning algorithms. We have developed a machine learning model based on neural networks estimating $PM_{2.5}$ from satellite-retrieved aerosol optical depths (AOD). In another effort, we developed an ML model to downscale 25 km (~ 15.53 mi) $PM_{2.5}$ estimates to 5 km (~3.1 mi) resolution over the Mekong region in Thailand.

In summary, our research is a multidisciplinary endeavor with profound significance for science, public health, and the nation's well-being. It has advanced our capability to estimate $PM_{2.5}$ pollution in near real-time at a very fine resolution for more informed policies and cleaner air for all.

Astrophysics and Heliophysics

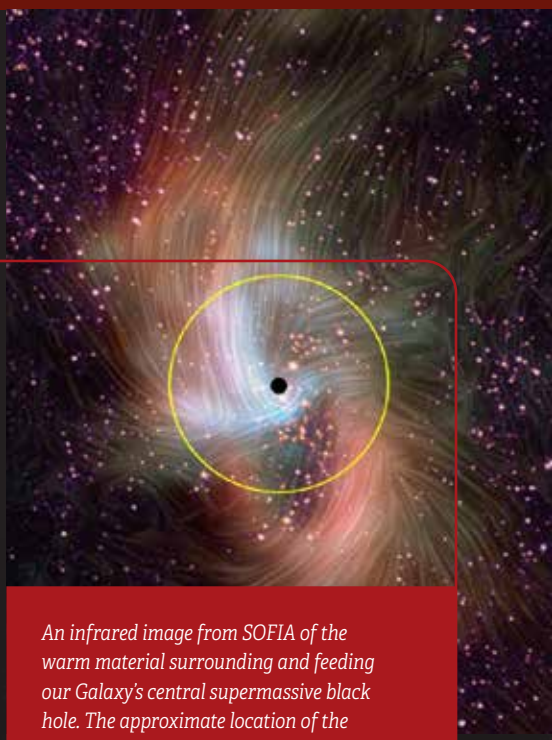
USRA scientists, in collaboration with scientists around the world, are contributing to our understanding of a wide array of current astrophysical problems, using nearly the full range of the electromagnetic spectrum. Current work enabled by USRA includes the turbulent youth and explosive death of stars, the largest gravitationally bound structures in the universe, the behavior of matter under the most extreme conditions, the origin of gravitational waves and high-energy cosmic rays, and the creation of the universe itself.

Probing the Heart of the Milky Way: SOFIA's Key Findings on Supermassive Black Hole Dynamics

The Stratospheric Observatory for Infrared Astronomy observations (SOFIA) discovered the limits of the gravitational influence of the supermassive black hole at the heart of our Galaxy. Supermassive black holes exist at the center of most galaxies. The center of our Milky Way galaxy is inhabited by a black hole four million times more massive than the Sun and is orbited by a large ring of material composed of gas and dust. Apart from the obvious gravitational influence that the black hole has on its surroundings, another force is at play, assisting in the feeding the black hole -- magnetic fields.

SOFIA mapped out the magnetic fields around the black hole in unprecedented detail and discovered that more than 3 light years away from the black hole, the magnetic field is strong enough to dominate and channel the accretion of material inward. However, within three light years of the black hole, the gravitational attraction is so strong that it pulls both the material and its magnetic field inward toward their final fates. This result provides further insight into the nature of supermassive black holes, the study of which is crucial for testing the fundamental laws of physics and understanding how galaxies like ours form and evolve.

(Reference: Jordan A. Guerra et al. 2023, Astronomical Journal, 166, 37)



An infrared image from SOFIA of the warm material surrounding and feeding our Galaxy's central supermassive black hole. The approximate location of the supermassive black hole is given by the black dot at the center. Overlaid are streamlines showing the orientations of the magnetic field lines. Inside the yellow circle SOFIA results find that gravity dominates the motion of the material, and outside the magnetic fields dominate. Image Courtesy: NASA/SOFIA.

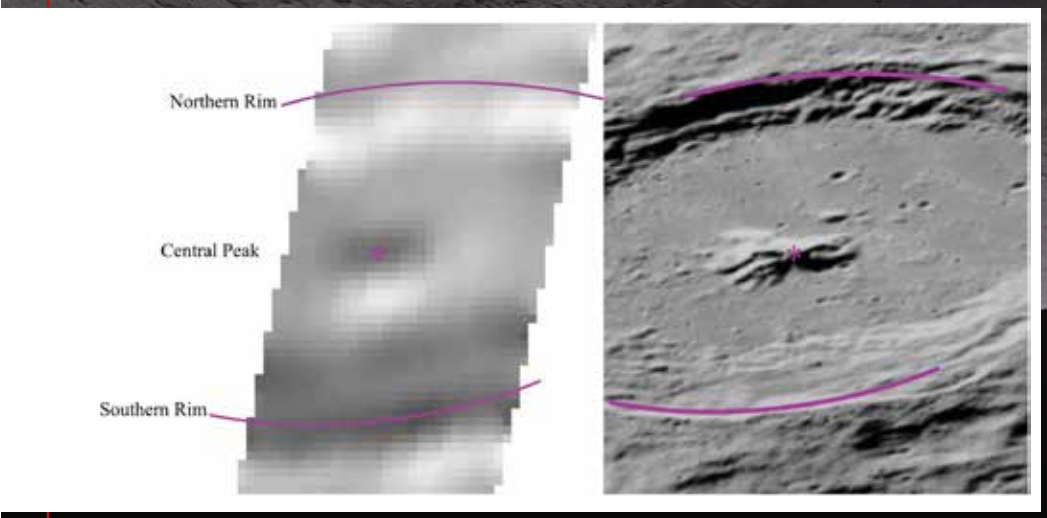
SOFIA's Milestone: Measuring Heavy Oxygen in Earth's Upper Atmosphere

SOFIA made the first-ever groundbreaking measurement of heavy atomic oxygen in Earth's upper atmosphere. Heavy oxygen with 10 neutrons, (as opposed to the standard eight) is associated with life and is prevalent in the lower atmosphere. While both forms are byproducts of photosynthesis, little is known about how this abundance of heavy oxygen extends from the location of its creation near the ground into higher regions of the atmosphere.

SOFIA measured the ratio of typical to heavy oxygen in the mesosphere and lower thermosphere, making the first detection of heavy oxygen outside a laboratory. This elevated presence of heavy oxygen in these regions is due to the upward and downward air movement which can have important implications for climate change. In the future, similar techniques could help assess oxygen ratios on exoplanets, potentially revealing signs of biological activity, though such endeavors would require advanced technology.

Water on the Moon—Insights from SOFIA's Infrared Astronomy

A team of researchers including one from USRA used the Stratospheric Observatory for Infrared Astronomy, to map the distribution of water around the lunar south pole. The new map shows for the first time how the water distribution is influenced by high-altitude features on the surface. A large crater (named Moretus) at 75 degrees south latitude shows that water is relatively highly concentrated on steep shaded slopes that face away from the Sun. In contrast, the steep slopes that face toward the Sun have lower concentration of water than their surroundings. Water exists well beyond the polar shadowed regions where there are ice deposits and which are the landing sites planned for NASA's Artemis base.



The visible -light image of Moretus crater (right) shows a dark shaded region inside the northern rim and a prominent central mountain with a shaded southern side. The water image (left) shows where there is more water (white) and average water (grey) or less water (black). Image Courtesy: Visible-light image -NASA Lunar Reconnaissance Orbiter; Infrared water image—SOFIA/ W. Reach/ USRA.

Dwarf galaxy J1440J144013+024744 as seen by NASA's Hubble Space Telescope. NASA's NuSTAR observatory picked up high energy X-ray signals from the activity of the massive black hole deeply hidden in the center of this dwarf galaxy, shown as an artist's conception in the zoomed image. Image Courtesy: NASA.

Discovery of An Intermediate Black Hole

The discovery of an intermediate black hole buried in gas and dust in a dwarf galaxy may provide clues about how such black holes were seeded in the very early universe. USRA's Dr. Chien-Ting Chen was co-investigator and Shrey Ansh, the lead author and graduate student at the University of Alabama in Huntsville, found a black hole to be deeply buried by the gas and dust in the galaxy. With the confirmation of the dust-obscured monster, scientists should have a better idea of where to look for these, getting closer to getting a complete census of the black hole population.

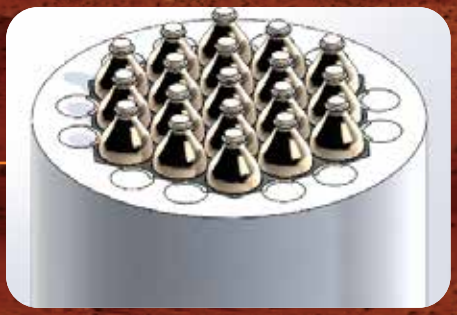
Supporting Heliophysics Research: USRA's Role in the PHaSER Agreement

USRA's Dr. Linda Neergaard Parker is a co-investigator on the five-year Partnership for Heliophysics and Space Environment Research (PHaSER) cooperative agreement for NASA/Goddard Space Flight Center (GSFC) Heliophysics division. This is the major cooperative agreement for GSFC Heliophysics work. Her team including Christopher Light and Preeti Bhanej focus on the following areas: Christopher Light supports the Space Weather Laboratory and has helped the Coordinated Community Modeling Center (CCMC) to validate science and research models for the community by installing, testing, and preparing models for the CCMC Runs on Request. Preeti Bhaneja supports the Mesospheric Physics Lab and has helped to make progress in the scientific understanding of planetary waves and their impact on ionospheric structure and instabilities through coordinated analysis of data from ongoing and past NASA Heliophysics missions, such as the Ionospheric Connection Explorer (ICON) spacecraft, the Global-scale Observations of the Limb and Disk (GOLD) spacecraft, and the Van Allen Probes, etc.

Space Nuclear Technology

Centrifugal Nuclear Thermal-propulsion Reactor (CNTR)

Future human exploration of Mars and the outer solar system will require the use of nuclear energy to reduce travel time and thus the exposure of the crew to energetic protons (i.e. cosmic rays and solar flares) in space. Such a reduction in travel time cannot be achieved using conventional rockets because of the lower exhaust velocities of the combustion gases. There are several concepts for attaining higher exhaust velocities (i.e. higher specific impulse) through the use of nuclear energy.



Top view of the CNTR showing the upper (turbine) ends of the 19 Centrifugal Fuel Elements surrounded by the 12 control drums. Image Courtesy: Zach Sakata, Center for Space Nuclear Research.

During 2023, the CSNR Summer Fellows considered an innovative design for nuclear thermal propulsion in which the uranium fuel is molten and retained within 19 rotating tubes using centrifugal force. This project, titled Centrifugal Nuclear Thermal-propulsion Reactor (CNTR) was sponsored by the NASA Marshall Space Flight Center in Huntsville, Alabama. The hydrogen propellant is forced through the porous tubes from the outside and then flows through the molten uranium and into the center of the tubes, attaining temperatures as high as 5000 K. The extremely high temperatures of the propellant result in specific impulses of 1800 s, twice as high as the specific impulse of the solid-fuel nuclear thermal propulsion reactors of the NERVA program and about five times the specific impulse of the conventional chemical rockets.

The eleven CSNR Summer Fellows produced a coordinated design that included thermal, hydrogen transport and structural models as well as the tube/turbine configuration and possible manufacturing methods.

Preliminary Modeling of Thermal and Structural Analysis of Centrifugal Fuel Elements (CFE)

Hydrogen flow velocities at the upper end of a Centrifugal Fuel Element of the CNTR. Image Courtesy: SolidWorks plot, Zack Sakata, Center for Space Nuclear Research.

A three dimensional model of the entire CNTR was made using SOLIDWORKS and the preliminary hydrogen flow path was analyzed with SOLIDWORKS Flow Simulation. A portion of that analysis, showing the closed end of the rotating porous tube is seen in the image on the left. The hydrogen gas goes up through the outer flow channel through the turbine and then down through the inner flow channel. The hydrogen then flows radially inward through the porous W-MO tube and then through the molten uranium before exiting out of the opposite end of the CFE. A MATLAB model of hydrogen flow parameters (pressure, temperature and velocity) through the porous media, calculates porous media internal stresses caused by temperature , centripetal forces and the difference in pressure of hydrogen (H_2) across the porous medium.

Based on thermal models of hydrogen propellant flowing radially inward through the porous tubes and the chemical reactions of the hydrogen and molten uranium with tube material, the investigators ranked the candidate materials and their overall suitability for use in the CNTR.

2023 CSNR Summer Fellows who worked at the Center for Space Nuclear Research. Image Courtesy: Center for Space Nuclear Research.

2023 CSNR Summer Fellows Zach Sakata (University of Idaho), Ana Almeida (University of Akron) and Aanchul Gupta (University of Illinois at Urbana-Champaign). Image Courtesy: Steve Herring/USRA.

Quantum Information and Data Science

Data Sciences using machine learning is enabling computers and other automated systems to perform tasks that have historically required human cognition and human decision-making abilities. USRA scientists and engineers have made significant contributions through foundational and use-inspired research and collaborative education projects in application domains that include Aviation Data Sciences and Environmental Data Sciences among others.

ExoMiner—USRA and NASA Data Scientists Validate 370 Exoplanets

In a groundbreaking discovery, in collaboration with NASA's Ames Research Center and other institutions, USRA/NAMS data scientists led groundbreaking efforts that have significantly contributed to the discovery and validation of 370 new exoplanets, thereby expanding our understanding of the cosmos. The achievements are further highlighted by the fact that approximately seven percent of the 5,425 confirmed exoplanets have been validated through the ExoMiner classifier neural network software.

The team published 8 papers in the *Astronomical Journal* and the *Astronomy Journal* and presented at Conferences including NeurIPS, and featured in a keynote lecture at the General Assembly International Astronomical Union. It has also been recognized by USRA, NASA Ames, NASA JPL, featured on the NASA Exoplanet website, and covered by many news outlets.

ExoMiner validated the 301 planets using data from the remaining set of possible planets – or candidates – in the Kepler Archive. All 301 machine-validated planets were originally detected by the Kepler Science Operations Center pipeline and promoted to planet candidate status by the Kepler Science Office, but until ExoMiner, no one was able to validate them as planets.

Machine Learning Shaves Minutes off Flights in Sustainable Aviation Demo

USRA's research initiatives in Artificial Intelligence and Machine Learning for aviation projects encompass extensive support for the NASA Aeronautics Research Mission Directorate's Airspace Operations and Safety Program. These projects are conducted in collaboration with the NASA Aeronautics Research Institute (NARI) and are funded by the Federal Aviation Administration (FAA).

In partnership with NASA's Ames Research Center, NASA's machine learning capabilities were successfully demonstrated as part of a sustainable aviation project at Dallas Fort Worth International Airport, in conjunction with American Airlines, Southwest Airlines, and Envoy Airlines, spanning from January through mid-December.

Remarkably, in the inaugural week of the demonstration, a Trajectory Option Set (TOS) service, powered by machine learning within the Collaborative Digital Departure Re-Route (CDDR) system, identified its first successful TOS re-route, significantly reducing flight distance by 35.9 nautical miles. This not only saved the flight 4.7 valuable minutes of travel time but also yielded substantial environmental benefits, resulting in 162 kilograms of fuel savings and a reduction of 498 kilograms of CO_2 emissions – equivalent to the positive impact of 8.2 urban trees.

This achievement marks a promising start for Sustainable Aviation Demonstrations employing machine learning, building on the success of the preceding Airspace Technology Demonstration 2 (ATD-2) project from the previous year, which demonstrated substantial benefits in optimizing airspace operations through physics-based models and field experiments involving major airlines at prominent airports.

Quantum Research and Development

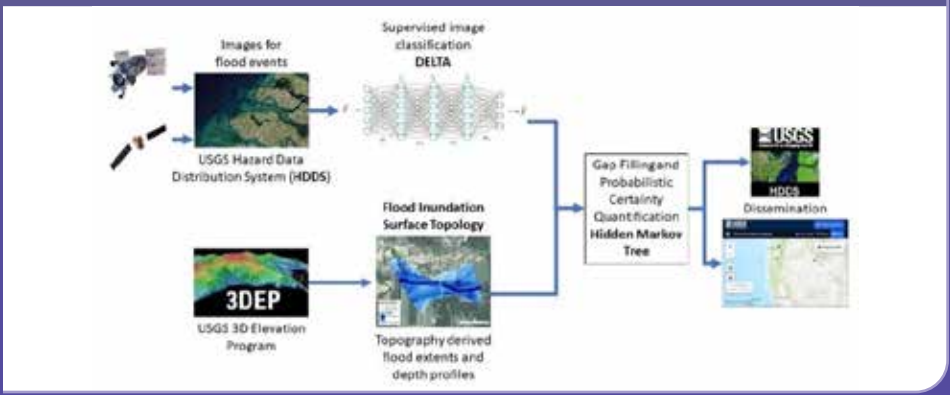
Quantum Artificial Intelligence Laboratory (QuAIL)
USRA's Research Institute for Advanced Computer Science (RIACS) conducts research in quantum computing as part of the Quantum Artificial Intelligence Lab at NASA's Ames Research Center. This research supports NASA's missions and involves collaboration with two Department of Energy (DOE) National Quantum Initiative Centers. It also involves collaborations with other federal programs including multiple Defense Advanced Research Projects (DARPA) programs. The team performs a wide range of research, which includes development and analysis of quantum machine learning and optimization methods in applications such as wildfire research and advanced air mobility. This year the team published twenty papers in peer-reviewed journals and conference proceedings, and submitted an additional twenty-four papers which are under review.

University Collaborations & Feynman Academy
The quantum team has active research collaborations with Princeton University, looking at applications of quantum computing in wireless network systems, and Stanford University where the team is focusing on applications of quantum computing in Neural network verification used in robotic systems such as unmanned aerial vehicles. In FY 2023, USRA partnered with North Carolina A&T in the recently awarded ExpandQISE program, supporting workforce development activities, including use of open-source software, mentoring students, promotion of ecosystem and organization of workshops. The program also supports research and development of nonlinear methods and linear solvers as well as co-lead in quantum machine learning for hypersonic flow models. In addition to these collaborations, 16 interns from different U.S. universities were supported through the USRA Feynman Academy internship program for remote internships working on a wide array of research projects targeting theory and analysis of near-term architectures and algorithms supporting both NASA and NSF programs.

Unveiling the Precision of Neural Networks in Flood Mapping

USRA researchers continued their research on the multi-agency DELTA-IRONFIST project. This collaborative endeavor involved USRA, NASA, USGS, NGA, and the University of Alabama. The research demonstrated use of neural networks on satellite imagery with a deep learning framework, for the purpose of classifying flood -prone areas in regions of high error rates. These errors often occur in areas where optical imagery from satellites is obstructed by natural elements such as vegetation or clouds. Initial experiments demonstrated impressive high levels of precision (98 percent) and recall (94 percent) with deep learning classification of satellite imagery combined with topography-based flood maps and Hidden Markov Tree models.

The project utilizes the NASA developed Deep Earth Learning, Training, and Analysis (DELTA) and software framework for classifying the satellite imagery and topography -based flood maps. The USGS commenced the process of transmitting the software for production use.



Data Science for Environmental Analytics

The environmental analytics data science group submitted or published 12 publications in FY 2023 with papers appearing on the cover of *Remote Sensing* for work in developing machine learning methods for wildfire detection. The team supported projects from NASA, USGS and DHS, investigating earthquakes, flooding, drought, wildfires, environmentally-informed forecast models for viruses and stratification of aerosols in cities.

Science and Facility Management

USRA manages various facilities. Summarized below are some of the facilities it operates.

XSPACE at LPI

Led by Dr. Cyrena Goodrich of the LPI, the XSPACE (eXterrestrial SamPle, Analyses, Curation, and Exploration) Laboratory (https://www.lpi.usra.edu/science/science-labs-equipment/xspace/) is a facility dedicated to the classification and curation of meteorites.

XSPACE

The Nomenclature Committee of the Meteoritical Society recognized XSPACE as an official meteorite repository in 2022. Meteorite classification is led by scientists at the Astromaterials Research and Exploration Science Division (ARES) of Johnson Space Center in partnership with scientists at the LPI. The primary source of these meteorites is Africa, but other non-Antarctic sources are considered as well. New meteorites submitted to XSPACE are examined and documented in hand samples at LPI (USRA-Houston) using optical microscopy and/or the LPI Phenom XL Scanning Electron Microscope. Those worthy of further study are transferred to Astromaterials Research and Exploration Science for additional preparation and analyses needed for classification. The XSPACE meteorite collection consists of a small number of donated meteorite samples, with additional donations anticipated. New meteorites are being classified and will become part of the collection.

Artificial Intelligence R&D Testbed

USRA's RIACS operates a computational testbed for Artificial Intelligence R&D in collaboration with the University of California, San Diego. The testbed provides access to the high-performance Graphic Processing Unit (GPU) and storage nodes for select university research projects aligned with USRA activities. The testbed is used by a growing portfolio of projects with faculty and student collaborators including new capabilities for collaborative research on Generative Artificial Intelligence (GenAI).

North Texas Research Station

Engineers in USRA's NAMS Team develop and operate the North Texas (NTX) Research Station in collaboration with NASA's Ames Research Center. NTX is a 5000 square-foot dedicated, air traffic management research facility. NTX has a dedicated radio tower and a reconfigurable computer lab, with access to live data including Air Route Traffic Control Center and Terminal Radar Approach Control Facilities data from Dallas/ Fort Worth and Dallas Love Field airports. The NTX team collaborates with the airline operation centers for American Airlines, Southwest Airlines, and Envoy Airlines. During the past year, benefits of the NASA Digital Information Platform (DIP) project were tested as part of a sustainable aviation demonstration at Dallas/Fort Worth airport with American Airlines, Southwest Airlines, and Envoy Airlines.

Aeronautics R&D Testbed for Airspace Operations

Engineers in USRA's NAMS team are developing and operating an aeronautics R&D Testbed for airspace operations with engineers at NASA's Ames Research Center. The core purpose of the Testbed is to enable realistic simulations of current and proposed future air traffic concepts for use by government, industry, and academia. The USRA team was involved with key simulations such as origin- to-destination, trajectory-based operations, widespread integration of novel vehicles and operations such as unmanned vehicles, and real-time safety assurance technologies to enable autonomous operations. As part of this work, the team supports industry partners, who provide real-world use cases and challenges to the team. During this past year, NAMS personnel released enhanced Aviation Systems TestBed capabilities and improved usability in support of NASA projects to integrate domestic and international partner software with NASA systems for upcoming simulations and flight demonstrations.

STEM Workforce Development

Internships, Fellowships and Scholarships

USRA's extensive workforce development pipeline provides immersive and experiential learning opportunities for K-12, undergraduate, and graduate students, as well as postdoctoral fellows and early career professionals.

Charting the Course for Tomorrow's Leaders

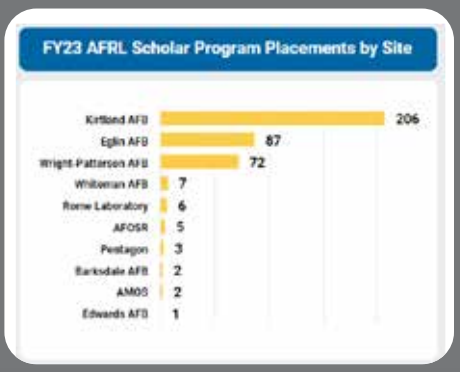
USRA's expansive portfolio of workforce development programming spans K-12 through the higher education continuum, and focuses on the recruitment, retention, and placement of students in the high-tech workforce of the future. USRA's STEM Education Center provides underserved and underrepresented students with early exposure to science, technology, engineering, and mathematics (STEM) programming, in an effort to increase retention and stimulate interest in degree and career fields.

During FY 2023, the STEM Education Center explored international partnership opportunities with Luxrobo. Research-focused internships offered through the Air Force Research Laboratory (AFRL) Scholars Program provided high school, undergraduate, and graduate students with the unique opportunity to contribute to the broader agency mission. USRA's flagship programs at Kirtland Air Force Base and Eglin AFB attracted more than 2,900 applicants this year, a 20 percent increase. In addition, USRA led the University Consortium Research Opportunity—a cooperative effort conducted in parallel with both AFRL and the United States Space Force (USSF) to provide funding to institutions of higher education for scientific and technical research.

AFRL STEM Workforce Development Programs: Where Experience Meets Inspiration

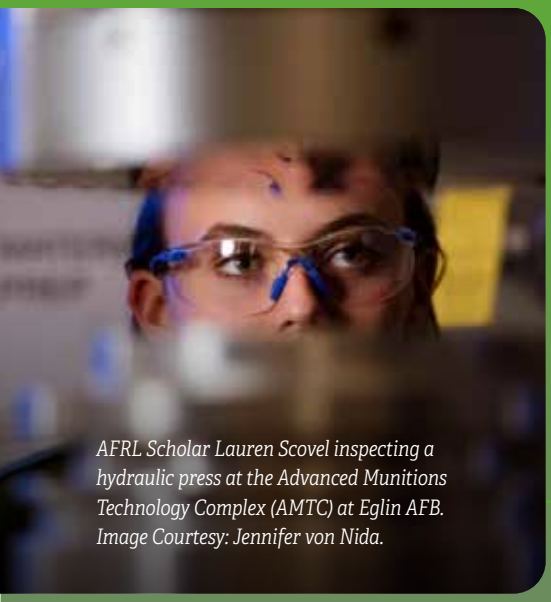
The Air Force Research Laboratory Scholars Program experienced its largest year since program inception in 2013 placing 391 students—a 19 percent increase from FY 2022—with 10 Technical Directorates (TDs) at 11 sites across the United States. The program expanded to include initial placements at Edwards Air Force Base (AFB) in Edwards, California, with the Aerospace Systems (RQ) TD and Whiteman AFB in Knob Noster, Missouri, with the AFWERX (RG) TD and the Materials and Manufacturing (RX) TD. USRA's flagship programs at Kirtland Air Force Base and Eglin AFB supported 206 and 87 interns respectively, while Wright-Patterson AFB, the Pentagon, and the expanding portfolio of satellite sites supported 72, 3, and 23 placements respectively.

The Scholars Professionals (SPs) program allows early-career graduates with Bachelor's, Master's, Doctorate, and Juris Doctorate degrees to pursue mentor-developed research conducted under the supervision of a Kirtland AFB mentor. SPs are selected for a one-year, full-time appointment with the opportunity to renew for up to three years. The first SPs participant began a one-year appointment during January 2023 in support of the Space Vehicles (RV) TD performing research related to the detection of x-rays produced from electrons.



Map of AFRL Technical Directorates and sites supported during FY 2023. Image Courtesy: USRA

The second cycle of the University Consortium Research Opportunity (UCRO 2.0) was launched with a Notice of Intent announcement in March 2023. The $6 million funding opportunity, administered by USRA, represented a critical partnership between the USSF and AFRL. UCRO 2.0 was focused on technologies needed to ensure continued and enhanced capability across all space areas, including moons and planets, for the U.S. military and civil operations through a network of partners. Universities with expertise in Beyond Geostationary Orbit (xGEO) and Space Domain Awareness (SDA) were encouraged to collaborate with each other and industry to address space research,



AFRL Scholar Lauren Scovel inspecting a hydraulic press at the Advanced Munitions Technology Complex (AMTC) at Eglin AFB. Image Courtesy: Jennifer von Nida.

development, and demonstration needs. Nine consortiums submitted proposals, representing 26 unique institutions. After a competitive solicitation process, both the Regents of University of Colorado (University of Colorado Boulder) and Virginia Polytechnic Institute and State University, along with their consortium partners, were selected to receive a combined total of $6.4 million over a two-year period of performance.

AFRL Scholar Clint Hinrichs using the headset on a C70 plane at Eglin AFB. Image Courtesy: Jennifer von Nida.

SOFIA Internships

In this Program, in collaboration with Santa Clara University, students were recruited to participate in observing runs at Lick Observatory to experience professional level observing.

After the spring semester ended, they spent the summer (typically 10-12 weeks) co-located with USRA staff at NASA Ames Research Center carrying out research, primarily in astronomical polarimetry, under the direction of USRA's B.G. Andersson and Kristin Kulas, but also including local postdoctoral fellows.

Feynman Quantum Academy Internship Program

USRA founded the Feynman Quantum Academy to help train the next generation of quantum information scientists. Interns focus on research in noisy intermediate scale quantum computing (NISQ) within the areas of theory, optimization, machine learning and benchmarking. The students receive hands-on training and undertake individualized research projects in quantum computing including compilation methods, quantum machine learning algorithms, analysis on the impact of noise in quantum algorithms, as well as software tools for quantum optimization and machine learning. Since launching in 2016, the Feynman Quantum Academy has hosted over 58 students from top international universities. Students have performed research across a wide array of quantum architectures. The program operates within the Quantum Artificial Intelligence Laboratory (QuAIL) and the NAMS R&D Student Program at NASA Ames, with several students being co-sponsored between NASA, DLR, NSF, AFRL, USGS and DARPA. Students and staff work collaboratively on projects, which often leads to opportunities for publication or conference presentations.

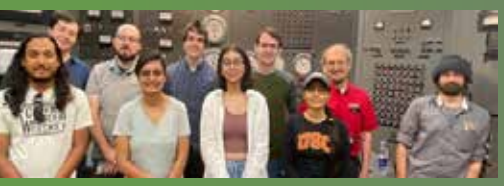
In FY 2023, the USRA Feynman Quantum Academy had another excellent cohort of student interns. Twenty-two intern projects were supported through the Feynman Academy internship program, a twenty-two percent increase from FY 2022.

Diana Chamaki presented her recent work on Self-consistent Quantum Iteratively Sparsified Hamiltonian algorithm (SQuISH). Image Courtesy: USRA / D. Chamaki.

STEM Workforce Development *Continued*

Internships, Fellowships and Scholarships

CSNR Internships



CSNR held its first in-person Summer Program since 2019 with nine students at INL and one attending virtually from Ann Arbor, Michigan. This program was funded by NASA Marshall Spaceflight Center and NASA's Space Nuclear Propulsion Program. The Summer Fellows participated in a multi-facetted design study of a bimodal reactor to provide both nuclear thermal propulsion (NTP) and electrical power to a series of round-trip missions to Mars. The neutronics analysis of the reactor indicated that it could complete five NTP missions and provide 2.5 megawatt (MWe) for on-board electrical needs over the course of 20 years. Afterwards, the reactor could be imbedded in the lunar or Martian regolith and provide 2.5 MWe of fission surface power for about 25 years. The team also analyzed thermal and structural performance, hydrogen diffusion during engine shutdown, thermophysical properties of advanced materials using density functional theory and the use of molecular laser isotope separation to enable the use of lower enrichment (i.e. HALEU) fuel.

Lunar and Planetary Institute Summer Intern Program (LPI)

This year's intern program included an international cohort from the United States, Canada, United Kingdom, and India. Image Courtesy: Lunar and Planetary Institute.

Each summer beginning in 1977, the LPI has played a vital role in attracting, training, and nurturing future planetary scientists through a 10-week summer intern program. The 2023 class included 13 undergraduate students from universities across the United States, United Kingdom, Canada, and India. Each intern worked one-on-one with a scientific mentor from the LPI or the NASA Johnson Space Center (JSC) to carry out a complete, end-to-end research project.

This year's intern program was held in person with virtual components. The program included scientific seminars on a variety of planetary science topics designed to provide an overview of the field, as well as five professional development seminars, a final conference presentation, evening socials, and virtual and in-person JSC laboratory tours.

Interns can submit their research to the upcoming 55th Lunar and Planetary Science Conference in 2024. Many projects also proceed to a final publication in a peer-reviewed scientific journal.

2023 Exploration Science Summer Interns. Image Courtesy: LPI.

NAMS R&D Student Program

USRA NAMS R&D Student Program continued to engage a diverse set of students from colleges and universities, including Minority Serving Institutions (MSIs), Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCU) and students in underserved communities.

This year, 82 virtual and on-site student internships were successfully completed. The interns were able to enrich their educational experience by participating in career development activities such as NAMS virtual activities, including the virtual presentation symposium, seminar series program, lightning talks, and networking events both in person and virtually. NAMS R&D Student Program partnered with NASA Ames Aeronautics division to recruit students from San Jose State University (MSI), UC Berkeley, and local community colleges to support aeronautics research and workforce development opportunities.

Exploration Science Summer Intern Program (Graduate)

The Center for Lunar Science and Exploration's (CLSE) summer intern program, led by LPI's Dr. David Kring, is designed to host five to ten graduate students who have a keen interest in assisting NASA and its international partners examine options for a new era of robotic and human exploration using the Orion crew vehicle, Human Landing System, and other assets being developed for missions beyond low-Earth orbit. The Exploration Science Summer Intern program is open to graduate students in geology, planetary science, planetary astronomy, and related programs.

The Intern program has been recently motivated by Space Policy Directive – 1, which directs NASA to deliver humans to the Moon for long-term exploration and resource utilization. NASA has, in response, developed the Artemis program and plans for a human landing in 2025. This year's Exploration Science Summer Intern program examined the distribution of impact ejecta from the Moon's largest impact basin, the South Pole-Aitken (SPA) impact basin, as well as primordial, pre-SPA crust that crystallized from a magma ocean, and post-SPA ejecta that covers the region. Modeling and mapping of those units can be used to identify the best locations to land to address Artemis science objectives.

In early August, students briefed their results to the LPI and Johnson Space Center communities. Their results will be incorporated into abstracts for the 55th Lunar and Planetary Science Conference in 2024 and a full-length, peer-reviewed journal article.

LPI Programs Engage the Science Community, Informal Educators, and Public

The Lunar and Planetary Institute conducts science engagement programs, supports scientists' professional development, and disseminates resources. Programs for students and early-career researchers raise awareness of planetary science research and opportunities, develop practical skills, and provide opportunities for networking and community building. Programs for other audiences increase awareness in and convey the excitement of planetary sciences.

Through the Planetary Resources and Content Heroes (ReaCH) program, LPI and partners conduct multi-day workshops for planetary scientists and informal educators to share strategies for engaging Black and Latinx communities in planetary science.

LPI science engagement programs prioritize partnering with institutions serving largely Black and Latinx communities and communities with lower socio-economic demographics. Participation at local in-person events included STEM fairs at school districts serving large percentages of disadvantaged youth, a Girls' space science STEM event, and multiple events at the nearby Pasadena Public Library, which serves a predominantly Hispanic/Latinx community, programs for students at local juvenile detention centers, and a camp for children with juvenile diabetes.

A moderated panel discussed ongoing Venus research during an LPI public engagement event in January 2023. Image Courtesy: LPI.

Summer Undergraduate Program for Planetary Research

The Summer Undergraduate Program for Planetary Research (SUPPR) is an 8-week internship program held from June to August. SUPPR invites undergraduate students who are interested in learning about research in planetary geoscience to participate. USRA pairs qualified undergraduates with NASA-sponsored planetary geology and geophysics investigators at locations around the country for eight weeks during the summer. The program is designed to help students gain educational experience in their fields of study while contributing to NASA missions and science.

The class of 2023 interns included eleven undergraduate students from the United States (including Puerto Rico) and India. Each intern works one-on-one virtually with NASA-sponsored planetary science investigators from various scientific institutions. In addition to their virtual individual projects, the interns participate in seminars, final project presentations, and virtual laboratory tours.

SUPPR Intern Meet and Greet on June 12, 2023. Image Courtesy: LPI.

USRA Distinguished Undergraduate Awards

Established to honor the service and memory of individuals who made significant contributions to their fields and to USRA, these awards are made possible by financial contributions, including those made by USRA Employees.

In keeping with its goal to recognize and develop promising future scientists and engineers in space-related disciplines, USRA bestows these awards to honor outstanding undergraduate students in a variety of majors through a competitive process. In 2022, USRA established the Judith L. Pipher Memorial Scholarship in honor of the former Trustee from the University of Rochester who had played an important role in the field of infrared astronomy and in USRA.

In 2023, we had 98 eligible applicants from 52 different universities, including 10 applicants from non-U.S. USRA members (one of whom won!).

The Following students were the winners of the 2023 Distinguished Undergraduate Awards

Shae Henley
University of Arizona
Thomas R. McGetchin Memorial Scholarship 2023 Awardee

Madison VanWyngarden
Boston University
James B. Willett Education Memorial Scholarship 2023 Awardee

Alicia Smith
University of Canterbury
Frederick A. Tarantino Memorial Scholarship 2023 Awardee

The Following Students Received Honorable Mention:

Juliane Hyvert
Mechanical Engineering
Northeastern University

Emma Kate Price
Mechanical Engineering
Harvard University

Rafael Ortiz
Astrophysics
Arizona State University

Giana Perez
Astrophysics
Stanford University

Stephanie Yoshida
Astrophysics
Harvard University

President's Award Recipients and Other Award Winners

The President's Awards is an annual formal program that recognizes employees who demonstrate extraordinary efforts above normal expectations of the job. Extraordinary achievement include a single noteworthy action, or a succession of extra efforts accomplished over a period of time.

The USRA President's Awards recognize outstanding achievements by all USRA staff, reflecting performance well above normal expectations for a given job assignment. The awards come in three categories, and include monetary prizes:

- USRA Distinguished Service Award: For sustained, exceptional contributions to USRA's mission and purpose by an individual, which reflect great credit upon USRA or its partner organizations in academe, government, and industry.
- USRA Individual Excellence Award: For excellence by an individual in research, development, or other areas, consistent with USRA's mission and purpose, that demonstrates USRA's values of Passion, Partnerships, and Professionalism.
- USRA Team Excellence Award: For excellence by a team in research, development, or other areas, consistent with USRA's mission and purpose, that demonstrates USRA's values of Passion, Partnerships, and Professionalism.

For 2022, our seventh year for these awards, the following staff were recognized by the President and CEO of USRA.

Tomohiro Oda, Earth from Space Institute

USRA Distinguished Service Award

Terri Jones, USRA Finance & Administration

USRA Individual Excellence Award

Erin Senoz, USRA Communications

USRA Individual Excellence Award

Hamed Valizadegan, NASA Academic Mission Services (NAMS) ExoMiner Team

USRA Team Excellence Award

Miguel Martinho, NASA Academic Mission Services (NAMS)

USRA Team Excellence Award

USRA's Manager Awards

USRA's Manager Awards recognize managers who demonstrate excellence in leading a team, managing the work, and positively affecting staff while demonstrating USRA Values: Passion, Partnerships and Professionalism.

Christine Dillard, Senior Program Manager for Internship Programs

Florida Hendricks, Senior Principal Manager, Contracts and Grants

Aaron Lott, Manager and Senior Scientist

Other Awards

The 2023 NASA Group Achievement Awards

Germán Martínez, USRA Senior Staff Scientist at LPI received the 2023 NASA Group Achievement Award for Mars 2020 Prelanding Strategic Science for his effort that maximized the scientific return of the early Mars 2020 Surface mission. He also received the 2023 NASA Group Achievement award for the Mars 2020 Meda instrument and the 2023 NASA Group Achievement Award for his role on the Mars 2020 Atmospheric Science team.

Allan H. Treiman, USRA Principal Scientist at the Lunar and Planetary Institute, received two 2023 NASA Group Achievement Awards for participation in both the Mars Science Laboratory (MSL) and Mars 2020 rover missions.

Air Traffic Management Machine Learning and Automation Awards

William J. Coupe, Alexandre Amblard, Sarah Youlton and Matthew Kistler received the Best of Track Award" for their paper on "Machine Learning Airport Surface Model."

Aida Sharif Rohani, Tejas G. Puranik, and Krishna M. Kalyanam received the Best of Track Award for Machine Learing Approach for the paper "Aircraft Performance Model Parameter Estimation for Trajectory Prediction Applications."

NASA Honor Award

Nine USRA Employees received the NASA Honor Awards including a TEAM Award for the **ATM-X UAM Team.**

NASA Early Career Award

Julie Stopar received the Susan M. Niebur Early Career Award presented by NASA's Solar System Exploration Research Virtual Institute (SSERVI). The award is given to researchers who are no more than ten years from receiving their terminal degree, who have shown excellence in their field, and who have demonstrated meaningful contributions to the science or exploration communities.

G.K. Gilbert Award

The Geological Society of America's Planetary Geology Division has selected USRA's **Allan Treiman** to receive the G.K. Gilbert Award. This division award is presented each year at the annual meeting in recognition of outstanding contributions to the solution of fundamental problems in planetary geology, which includes geochemistry, mineralogy, petrology, geophysics, geologic mapping, and remote sensing.

NASA Group Achievement Award

USRA's SERVIR Geospatial Information Technology (GIT) team (located in Huntsville, Alabama was awarded a NASA Group Achievement Award for the prompt implementation of ClimateSERV (https://climateserv.servirglobal.net), which facilitates analysis of rainfall, soil moisture, vegetation health and other important datasets derived from satellite observations and modeling systems, over user-defined areas of interest.

The SERVIR GIT Team which received the NASA Group Achievement Award in August 2023 is pictured above. (From left to right) Alexandre Goberna/USRA, Francisco Delgado/USRA, William Ashmall/USRA and Lance Gilliland/Jacobs; missing from the picture is Githika Tondapu/USRA).

Kuno Award

Kelly Stokes and **Srija Chakraborty** received the 2022 Kuno Award.

Other Recognition

Walter Kiefer was named as a member of the NASA Planetary Science Academic Committee.

Ethics and Compliance

The Ethics and Compliance Committee (ECC) ensures that USRA's policies and procedures are carefully crafted, well-communicated, effectively put into practice, and consistently enforced to prevent and detect any legal or ethical misconduct. The Chief Ethics and Compliance Officer (CECO) is central to this effort, offering ongoing guidance to senior management on ethical and compliance-related matters, enhancing internal resources for employees to uphold ethical standards, providing advisory opinions on ethical matters, and addressing ethics-related concerns.

The CECO maintains open lines of communication with the Board and USRA's senior management, keeping them informed about incidents and initiatives related to ethics and compliance. USRA continues to prioritize comprehensive ethics and compliance training for all employees, emphasizing the essential compliance responsibilities associated with federal contracts. It's worth noting that in the fiscal year 2023, *ALL* USRA employees completed the Ethics and Code of Conduct training, which included reporting mechanisms underscoring the organization's unwavering commitment to cultivating a culture of compliance and ethical integrity.

Some USRA employees may receive supplemental ethics training from NASA or other government agencies. USRA requires all employees to complete annual online training, which is delivered in three separate sessions, including: "Workplace Harassment Prevention," "Ethics & Code of Conduct," and "Avoiding Conflicts of Interest." All USRA leaders are expected to set an ethical tone and demonstrate a commitment to USRA's values through their actions. They also must promote an environment where compliance is expected, and ethical behavior is the norm.

USRA's Executive Compliance Committee ensures that USRA's policies and procedures are reasonably designed, communicated, implemented, enforced, and effective at preventing and detecting illegal and ethical misconduct. The ECC is also responsible for recommending and taking actions to sustain and cultivate an ethical and compliant organizational culture at USRA.

USRA requires all employees to take compliance training in several different areas to ensure that employees are fully informed of their obligation to comply with laws and regulations applicable to a federal contractor. It also facilitates external audits and retains the services of an independent legal counsel for guidance in issues related to ethics and compliance.

Diversity, Equity, Inclusion and Accessibility Committee

The DEIA Committee focused on leveraging our initiatives to create a more inclusive culture. To date, the DEIA Committee has thirteen Initiatives that have been defined and approved. As part of inclusion efforts, the DEIA Committee added "Accessibility" to establish DEIA. The DEIA Committee understands that USRA has employees from over a dozen different countries who are very proud of their cultures and background. Initiative 13- DEIA Cultural and Inclusion Calendar and Employee Highlight was approved to help to forward the goal to increase diversity, equity, inclusion, and accessibility in the USRA workforce. The purpose of this initiative is to implement a cultural and inclusion calendar with meaningful events and activities. A diversity and inclusion calendar is a tool that lists various cultural, religious, and social events, holidays, and awareness days from different groups throughout the year. The activity helps people learn about and respect the unique backgrounds, beliefs, and customs of others. This calendar helps to create a sense of belonging. Additionally, two inclusive initiatives were added to the onboarding process: Initiative 1 –USRA staff consider adding Personal Gender Pronouns to their e-mail signature; and Initiative 3 – USRA sets standards and uses templates for new employee introductions and promotion announcements. The committee also worked closely with Human Resources to ensure alignment and to drive inclusion throughout the organization. Examples of these activities include the addition of LinkedIn-Life at USRA and Bonusly Hashtag for DiversityEquityInclusion. Furthermore, the DEIA committee ensured representation on the DEIA Committee by adding functional representation as well as representation from across the institutes.

A screenshot of a virtual meeting of some of the members of the DEIA committee.

Governance and Member Universities

USRA is an association of 117 esteemed doctoral degree-granting universities deeply committed to advancing space and aeronautics research and education. Through its university membership, USRA maintains a robust and broad system of public oversight of the organization while pursuing its nonprofit mission dedicated to the advancement and practical application of space-related science, technology, and engineering.

The Board of Trustees constitutes the governing board of USRA, appointing the officers of the corporation, establishing policy, and conducting oversight. It meets three times a year.

The university members comprise a Council of Institutions. In a significant departure from virtual gatherings necessitated by the pandemic, the 2023 Annual Meeting was held in person. Key highlights of this event included reports from the President and CEO, as well as from the Chair of the Board of Trustees, outlining USRA's activities. Furthermore the Council deliberated and subsequently approved membership of the Indian Institute of Space Science and Technology. The Council also actively participated in the Annual Symposium on Cislunar Space, at which the keynote speaker was Robert Cabana, NASA Associate Administrator.

Several Science councils provide independent assessment to the USRA President, Board of Trustees and the relevant USRA institute director. They provide input from the broad research community and give the community a means to comment on USRA activities. They serve as a sounding board for questions on the course and advisability of current activities and future directions.

USRA Board of Trustees

FRONT: LEFT TO RIGHT

Dr. Joan Ramage Macdonald, COI Vice Chair, Lehigh University

Dr. Berrien Moore, III, Region VIII Trustee and Board Vice Chair, University of Oklahoma

Dr. Jeffrey Isaacson, President and CEO, USRA

Dr. Brian Gilchrist, COI Chair, University of Michigan

BACK: LEFT TO RIGHT

Ms. Kim Williams (Ret.) Chair, Audit & Finance Committee and At-Large

Dr. Daniel E. Hastings, Region I Trustee, Massachusetts Institute of Technology

Dr. Elizabeth A. Lada, Region IV Trustee, University of Florida

Dr. Sean C. Solomon, Region II Trustee, Columbia University

Dr. Kathleen C. Howell, Region VI Trustee, Purdue University

Dr. Wayne A. Scales, Region III Trustee, Virginia Tech

Dr. Truell Hyde, Region VII Trustee, Baylor University

Dr. Robert McCoy, Region IX Trustee, University of Alaska-Fairbanks

NOT PICTURED

Dr. Richard Ambrosi, Region V Trustee, University of Leicester

Maj. Gen. William N. McCasland (Ret.), At-Large, United States Air Force

Gen. Lester L. Lyles US Air Force (Ret.), Board Chair, United States Air Force

Dr. John A. Montgomery (Ret.), Interim, At-Large, Naval Research Laboratory

USRA Member Universities

Alabama A&M University
Arizona State University
Auburn University
Baylor University
Boston College
Boston University
Brandeis University
Brown University
California Institute of Technology
Case Western Reserve University
Colorado School of Mines
Columbia University
Cornell University
École Polytechnique Fédérale de Lausanne
Embry-Riddle Aeronautical University
Florida Institute of Technology
Florida State University
George Mason University
Georgetown University
Georgia Institute of Technology
Hampton University
Harvard University
Howard University
Indiana University
Indian Institute of Space Science and Technology
Iowa State University
Johns Hopkins University
Korea Advanced Institute of Science and Technology
Lehigh University
Louisiana State University
Massachusetts Institute of Technology
Michigan Technological University
Mississippi State University
Montana State University
New Jersey Institute of Technology
New Mexico State University
New York University
North Carolina A&T State University
North Carolina State University
Northwestern University
Ohio University
Oklahoma State University
Old Dominion University
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rice University
Rochester Institute of Technology
Seoul National University
Stanford University
Stony Brook University, SUNY
Technion - Israel Institute of Technology
Tel Aviv University
Texas A&M University
Texas Tech University
The Chinese University of Hong Kong
The George Washington University
The Ohio State University
The Pennsylvania State University
The Rockefeller University
The University of Alabama in Huntsville
The University of Arizona
The University of British Columbia
The University of Iowa
The University of Kansas
The University of New Mexico
The University of Oklahoma
The University of Sheffield
The University of Sydney
Tufts University
University at Buffalo, SUNY
University of Alaska - Fairbanks
University of Arkansas
University of Bern
University of California, Berkeley
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara
University of Canterbury
University of Central Florida
University of Chicago
University of Cologne
University of Colorado Boulder
University of Connecticut
University of Delaware
University of Denver
University of Florida - Gainesville
University of Hawaii
University of Houston
University of Illinois at Urbana-Champaign
University of Leicester
University of Maryland
University of Michigan
University of Minnesota
University of Nebraska - Lincoln
University of New Hampshire
University of Pittsburgh
University of Rochester
University of Southern California
University of Stuttgart
University of Tennessee, Knoxville
University of Texas at Arlington
University of Texas at Austin
University of Texas at Dallas
University of Texas at El Paso
University of Texas Medical Branch at Galveston
University of Toronto
University of Virginia
University of Washington
University of Wisconsin - Madison
University of Zurich
Utah State University
Vanderbilt University
Virginia Polytechnic Institute & State University
Washington University in St. Louis
William & Mary
Yale University

Council of Institutions

The USRA Council of Institutions (COI) ensures USRA is embedded within the broad university community involved in space science and aerospace technology and that USRA serves its public purpose. The COI elects new universities to membership, the Trustees that constitute the governing board, and sets the corporate bylaws.

COI Working Groups

In 2023, the Council of Institutions established the COI Science and Technology Working Groups, in which the university research community provides technical expertise on topics of specific interest to federal agencies for planning and implementing research strategies and new technology development. As communities of practice within the university research community, these working groups provide expert guidance on emerging trends, policy shifts, funding opportunities, technology development, institutional capacity building, and other areas of interest to federal agencies and universities. Their efforts also aide in building university research portfolios to meet national and international needs.

The Space Nuclear Working Group (SNWG) was established to address issues with regard to development of nuclear propulsion and nuclear electric power, issues of importance in planning future human missions to Mars. The SNWG will develop a space nuclear technology maturation roadmap outlining specific activities and tasks, along with a timeframe for accomplishments. The SNWG was established with seven faculty drawn from USRA member and non-member universities, who are experts in various aspects of space nuclear science and engineering. The Working Group is chaired by Prof. Jeffrey King (Colorado School of Mines).

COI Annual Symposium

Robert Cabana, Associate Administrator at NASA, delivered the Frederick A. Tarantino Memorial Address at the 2023 Symposium. Image Courtesy : Aaron Clamage.

The COI hosts an annual symposium in conjunction with its annual Meeting, The 2023 Symposium, held on March 23, 2023 explored the theme "Cis-Lunar Space, Research for Today, Training for Tomorrow." It gathered a diverse panel of experts from governmental and commercial sectors to deliberate on the future of Cis-Lunar space research. Robert Cabana, Associate Administrator at NASA, delivered the Frederick A. Tarantino Memorial Address, providing invaluable insights for academic institutions eyeing opportunities in CIS-Lunar space research.

Issues and Program Committee

The USRA Issues and Program Committee (IPC) operates under the Council of Institutions (COI) as an influential voice in public policy. The committee consists of esteemed professors from each USRA region. It is tasked with crafting policy stances, liaising with Congressional members and their aides, providing expert testimony, and spearheading the COI Annual Symposium in alignment with the COI Annual Meeting.

The USRA IPC for 2023 is under the leadership of Prof. Brian Gilchrist, COI Chair.

Public Policy Advocacy

Championing University Interests in Space Research and Education

Issues and Program Committee Leadership and Members

Chair:	Brian Gilchrist, University of Michigan
Vice Chair:	Joan Ramage Macdonald, Lehigh University
Region I	Josh Grindlay, Harvard University
Region II	Joan Ramage Macdonald, Lehigh University
Region III	Wayne Scales, Virginia Tech
Region IV	Isi Ero-Tolliver, Hampton University
Region V	Chris Damaren, University of Toronto
Region VI	Neil Cornish, Montana State University
Region VII	Truell Hyde, Baylor University
Region VIII	Steve Stochaj, New Mexico State University
Region IX	Bob McCoy, University of Alaska Fairbanks
Observers:	David Canales Garcia, Embry-Riddle University; Jed Hancock, Space Dynamics Lab, Utah State

Advocacy Efforts

On March 23, 2023, members of the Universities Space Research Association's Interdisciplinary Program Committee (USRA IPC) gathered on Capitol Hill. Their mission was to advocate for the advancement of space-related research and education. During these dialogues, they expressed gratitude to Congress for its ongoing support of NASA and academic funding. Before this Capitol Hill meeting, the IPC convened at the USRA Washington Office to formulate strategic objectives for their Fiscal Year 2024 advocacy efforts.

IPC members met staff from U.S. Senator Raphael Warnock (D-GA).

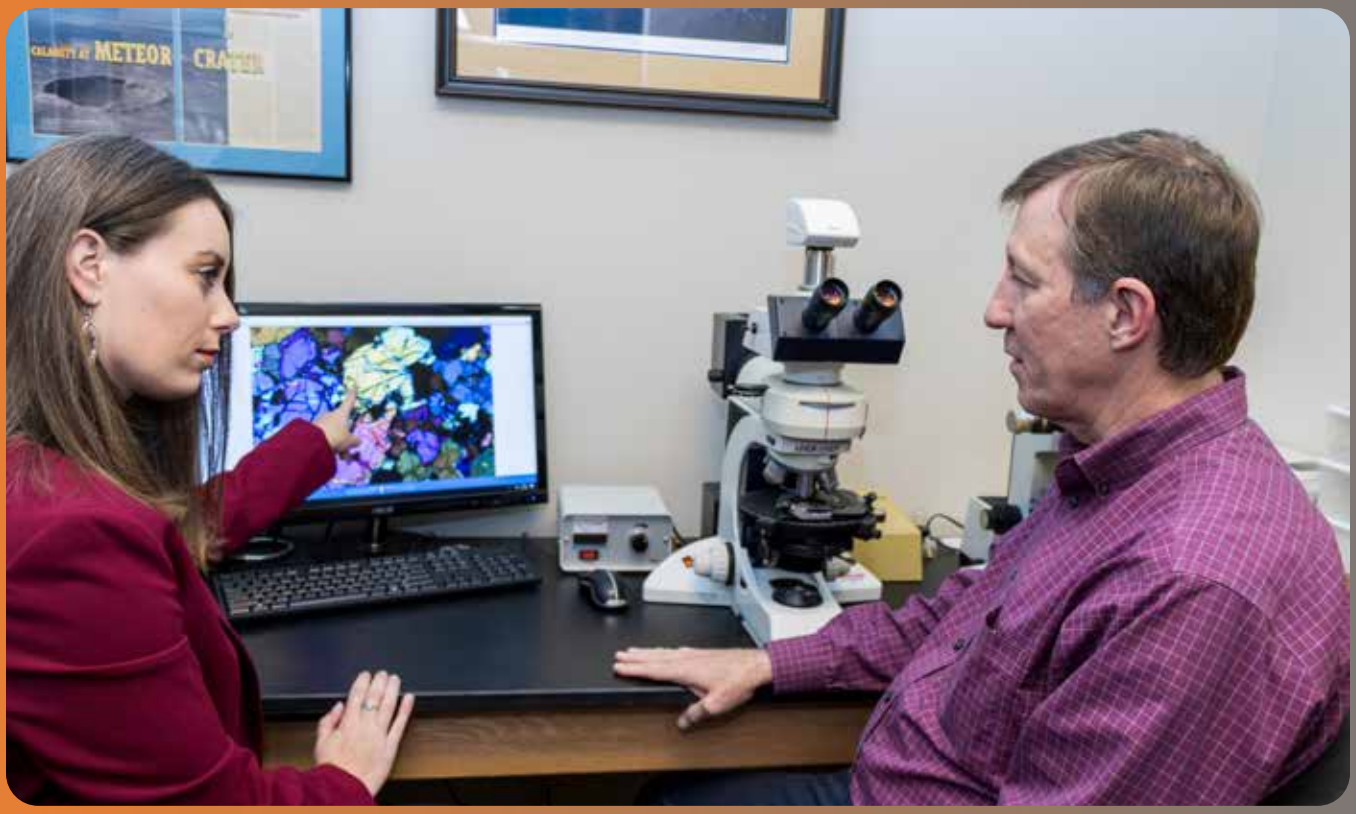
University Research Engagement

USRA's institutes and programs engage with universities and other organizations in research collaborations. These engagements are carried out in two ways. Engagements occur at the individual investigator level, where USRA scientists pursuing independent research submit joint proposals and publish papers with colleagues in academia and other organizations in the outside community. Larger engagements occur at the programmatic level, where USRA forms teams with universities to leverage the existing capabilities and resources present in the community in order to execute the operation of a large activity.

The table below provides summary data on individual investigator engagements in 2023.

Total Engagements involved 1,004 activities with 343 organizations

Type of Organization	Number of Organizations	Number of Research Engagements
Universities - USRA Members	89	402
Universities - Non-Members	145	253
Total Universities	**234**	**655**
Other Research Organizations	**109**	**349**
TOTAL	**343**	**1004**



Lunar and Planetary Institute scientists, Rachel Slank and David Kring discuss a microscopic image of a geologic sample from an astronaut training site. Image Courtesy: USRA/LPI.

The number of research engagements with universities were 655.

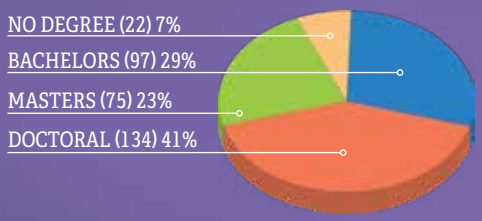
USRA increased its collaborations with Minority Serving Institutes from 94 in 2022 to 121 in 2023.

USRA's Council of Institutions voted to include the Indian Institute of Space Science and Technology as the 117th member university and the COI held five regional meetings.

USRA's first Space Nuclear Working Group was established with a new charter and mission served by faculty members from nuclear science and nuclear engineering departments across the nation.

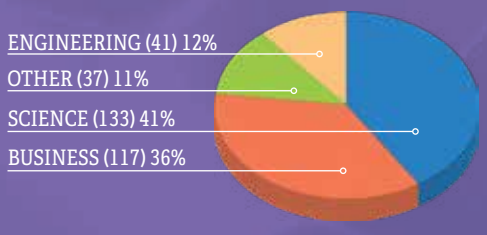
USRA's Diversified Workforce

Employee Distribution by Degree



Approximately 41 percent of USRA's workforce hold Doctoral degrees, and another 23 percent hold Masters.

Employee Distribution by Areas of Study

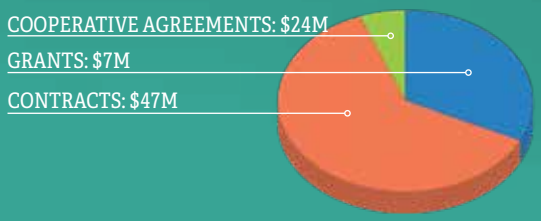


Approximately 63 percent of USRA's workforce comprises scientists and engineers.

Financial Highlights

FY 2023 Revenue Distribution

TOTAL REVENUE $78M



USRA's FY 2023 revenue was $78M, down from $111M in the prior year due in large part to the sunset of some legacy programs. Despite the lower revenue, USRA improved its overall cost position compared with FY 2022 with the sale of our Columbia building and other strategic cost savings initiatives. Overall the company exited FY 2023 healthier than in prior years, strengthening our balance sheet, improving its use of cash and removing any material Long Term Debt obligations. These actions, combined with over $18M of operating cash, better position USRA for long-term growth opportunities.

FY 2023 Assets

Total Assets: $48 million*
Net Assets: $38 million*

**Includes the non-cash impact on the loss from the sale of our former corporate headquarters in Columbia, MD. With the sale of the property, USRA has removed all Long Term Debt obligations from their balance sheet absent the long term lease agreement on the company's new corporate headquarters in Washington, D.C., compliant with ASC-842 reporting requirements.*

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Students measuring the physical properties (with cone penetrometers and a shear vane device) of material ejected from explosion craters that were produced by the United States Geological Survey to mimic an area near the Apollo 11 landing site. Image Courtesy: USRA/LPI.

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