

Capacity Building Program

2022 Annual Summary



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INTRODUCTION & OVERVIEW



EARTH SCIENCE
APPLIED SCIENCES

Welcome

The past year was one of significant growth and reimagining at NASA’s Capacity Building Program, and we are grateful to be able to share some outcomes and impacts of that growth with you in this annual summary. This year, our core elements doubled to incorporate the Indigenous Peoples Initiative, Prizes and Challenges, and Equity and Environmental Justice as part of Community Action, in addition to ARSET, DEVELOP, and SERVIR. This expansion provided ample opportunities for growth and collaboration, and our team responded with enthusiasm and a reliable zeal and passion for advancing the use of Earth information for societal benefit.

In addition to this expansion of our core offerings, our programs experienced several major “launches” in 2022. DEVELOP returned to in-person projects at all locations, while continuing to offer virtual opportunities. ARSET offered its first trainings related to Climate & Resilience and launched a quarterly newsletter to keep the growing community of trainees updated on the latest offerings. SERVIR launched the second phase of SERVIR West Africa in cooperation with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) as the implementor for the consortium in work related to agriculture and food security, water resources, land cover and land use change, and weather and climate for the next five years.

On the day-to-day, most of our work has transitioned back to a hybrid environment, and travel has returned. It has been a joy to reconnect with international colleagues and to work in-person with our teams yet again. In 2022, our team participated in numerous virtual and in-person meetings, conferences, and workshops, including GEO Week 2022 in Accra, Ghana, the Tribal GIS Conference, and the Groundwork USA National Assembly, to name a few. The Capacity Building Program continued to lead NASA’s Earth Science Applications Week in 2022, including two days in-person with the NASA DEVELOP teams and Applied Science interns at NASA Headquarters.

On behalf of the Capacity Building Program Team, I’d like to thank our many stakeholders, supporters, and the community that help us impact so many across the globe. This report provides just a preliminary view of our impacts, and I invite you to explore the Capacity Building webpage and our program offerings to learn more. On behalf of the entire Capacity Building family, we look forward to many more years of growth, partnership, and learning.

Nancy D. Searby, Ph.D.
Capacity Building Program Manager

Introduction

The Earth Science Division's (ESD) [Applied Sciences Program](#) (ASP) promotes efforts to discover and demonstrate innovative and practical applications of Earth observations. ASP activities collaborate with organizations across all sectors to apply scientific findings and satellite data in their decision-making activities. The Program has three primary lines of business: Applications, Capacity Building, and Mission Engagement. Program activities support our goals to deliver near-term uses of Earth observations, build capabilities to apply Earth science data, and collaborate with the science teams for NASA satellite missions.

The Applied Sciences' [Capacity Building Program](#) (CBP) strengthens skills of individuals and institutions around the globe to use Earth observations and increases awareness within non-traditional audiences of NASA Earth observations data, products, applications, and services. CBP engages across the ASP Application Areas' portfolios of Water Resources, Disasters, Ecological Conservation, Health & Air Quality, Agriculture, Climate & Resilience, Wildfires, and other applications of Earth information including Energy, Urban Development, and Transportation & Infrastructure. CBP works through both program and element activities. Program activities include participating in domestic and international capacity building groups, such as the Group on Earth Observations (GEO) and the Committee on Earth Observation Satellites (CEOS), as well as initiating inter-network groups such as the Earth Observation Training, Education, and Capacity Development Network (EOTEC DevNet). CBP includes four Center-based programmatic elements: the Applied Remote Sensing Training Program (ARSET), DEVELOP, SERVIR, and the Indigenous Peoples Initiative (IPI). CBP also includes two elements housed at Headquarters: Equity and Environmental Justice (EEJ) and Prizes & Challenges (P&C). IPI, EEJ, and P&C are part of our Community Action area.

Element Descriptions

[ARSET](#) provides accessible, relevant, and cost-free training on remote sensing satellites, sensors, methods, and tools. Through online trainings designed for all skill levels, the program teaches basic to advanced remote sensing skills to a worldwide audience using freely available data and software.

[DEVELOP](#) addresses environmental and public policy issues through interdisciplinary feasibility projects that apply NASA Earth science information and resources to community concerns. These projects provide experiential learning and workforce development opportunities for both participants and partner organizations to utilize geospatial data and resources and inform decision making processes.

[SERVIR](#) is a joint initiative of NASA, USAID, and leading geospatial organizations in Asia, Africa, and Latin America, that partners with countries and organizations in these regions to address critical challenges in climate change, food security, water and related disasters, land use, and air quality. Using satellite data and geospatial technology, SERVIR co-develops innovative solutions through a network of regional hubs to improve resilience and sustainable resource management at local, national and regional scales.

The Indigenous Peoples Initiative (IPI), part of Community Action, seeks to support and cultivate efforts within Indigenous communities and NASA to increase the use of Earth Observations (EO) to inform decisions, policies, and actions. The IPI team is uniquely positioned to foster respectful and reciprocal relationships between NASA and Indigenous communities to sustainably co-develop trainings, projects, and tools. The pillars of this work are centered around place-based remote sensing trainings, community engagement, and creating diverse Earth Science opportunities.

[Prizes and Challenges](#), also part of Community Action, crowdsources ideas, technologies, scientific advances, and other solutions from people around the world through incentivized competitions. By opening missions and questions, the number of people sharing interdisciplinary knowledge and collaborating to tackle challenges together multiplies – all increasing the likelihood of generating practical and effective solutions our planet’s toughest problems. The element partners with other federal agencies, international space agencies, and private organizations to host competitions, sharing focused, defined problems and awarding cash prizes, recognition, and other incentives for winning solutions. Prizes and challenges allow us to reach people with diverse backgrounds, skillsets, and experiences, and bring out-of-discipline perspectives and tools to the table.

The Equity and Environmental Justice (EEJ) element, the final component of Community Action, helps ensure Earth data can benefit everyone, regardless of race, color, national origin or income. The element provides resources to help communities across the US make informed decisions about issues affecting them. The element also builds new partnerships to support community outreach, training, and information and tools that use Earth observations. The element aims to create opportunities for people to utilize Earth observations and information – which empowers them with enhanced tools to protect and strengthen their community.

2022 Overview

Throughout 2022, the Capacity Building Program continued to build skills across a broad range of experiences, sectors, thematic areas, and geographies. In this section, you can explore the program’s general 2022 reach “by the numbers” and “by the map.” However, impact cannot always be measured in numbers and metrics; read our [Impact Stories](#) to learn more about the effect of our work on specific people and places.

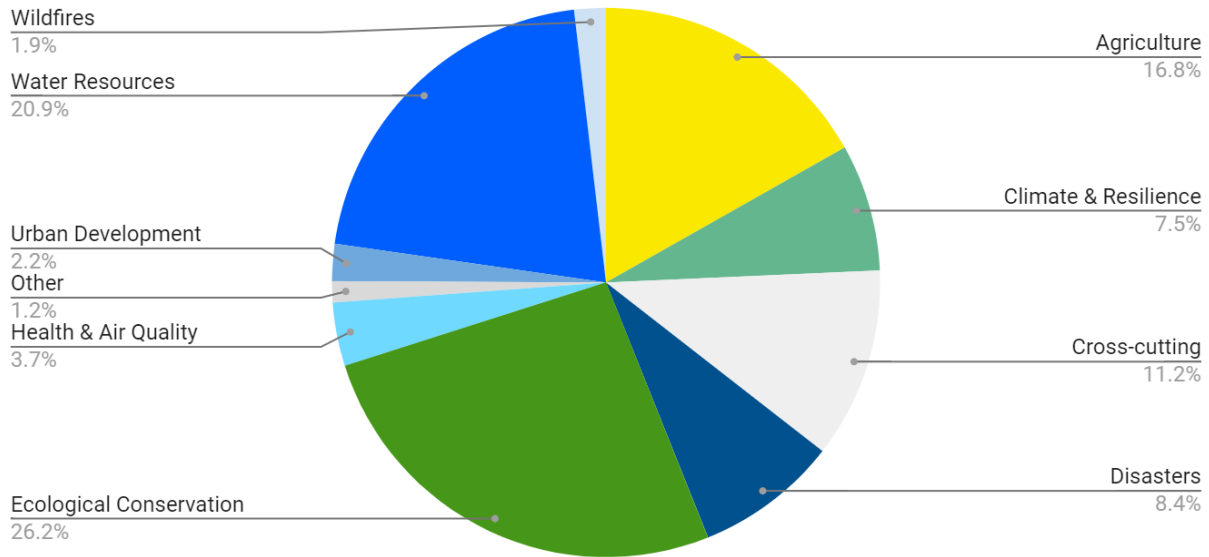
2022 By the Numbers

The Capacity Building Program engages individuals and institutions through a variety of skill-building methods: trainings, feasibility studies, partnerships, competitions, and projects. In 2022, the program conducted **198** trainings, **71** feasibility studies, and **135** projects. Representatives of CBP attended **182** meetings, events, and conferences around the world.

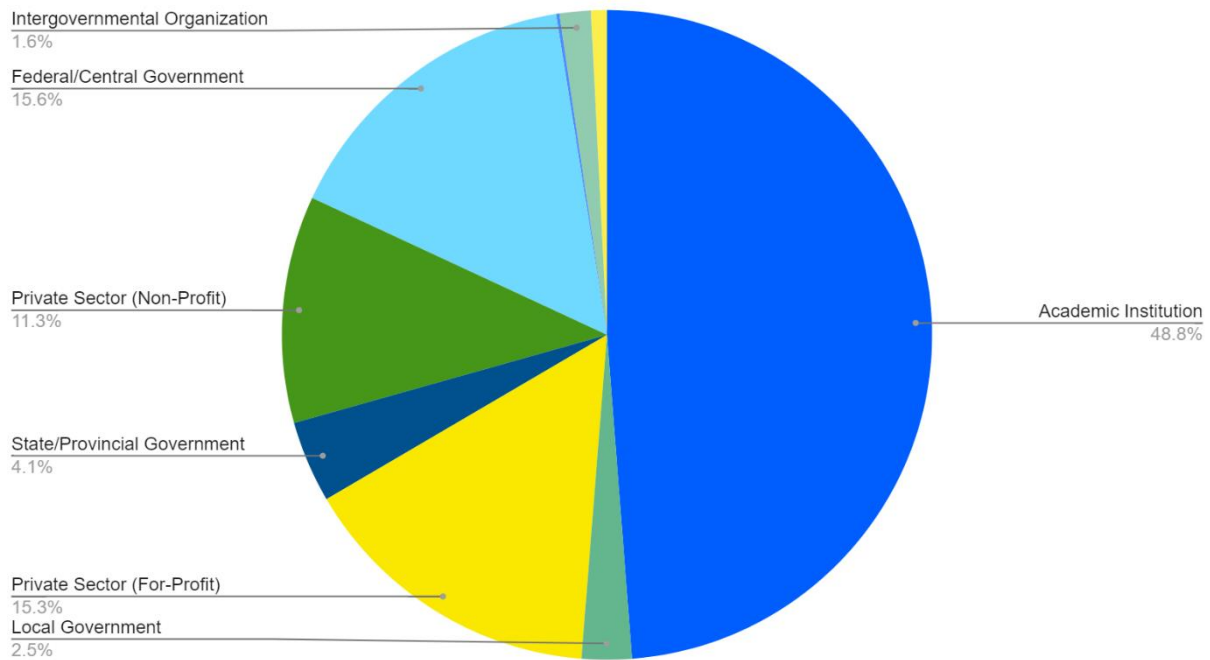


CBP activities addressed eight thematic topics in alignment with the Applied Sciences’ Application Areas: Agriculture, Climate & Resilience, Disasters, Ecological Conservation, Health & Air Quality, Urban Development, Water Resources, Wildfires, and topics that cut across these application areas. CBP also engaged with a wide variety of institution types, including academia, non-profits, tribal organizations, for-profit companies, and governments at the local, state/province, and federal/central level, as well as intergovernmental organizations.

Thematic Area Addressed

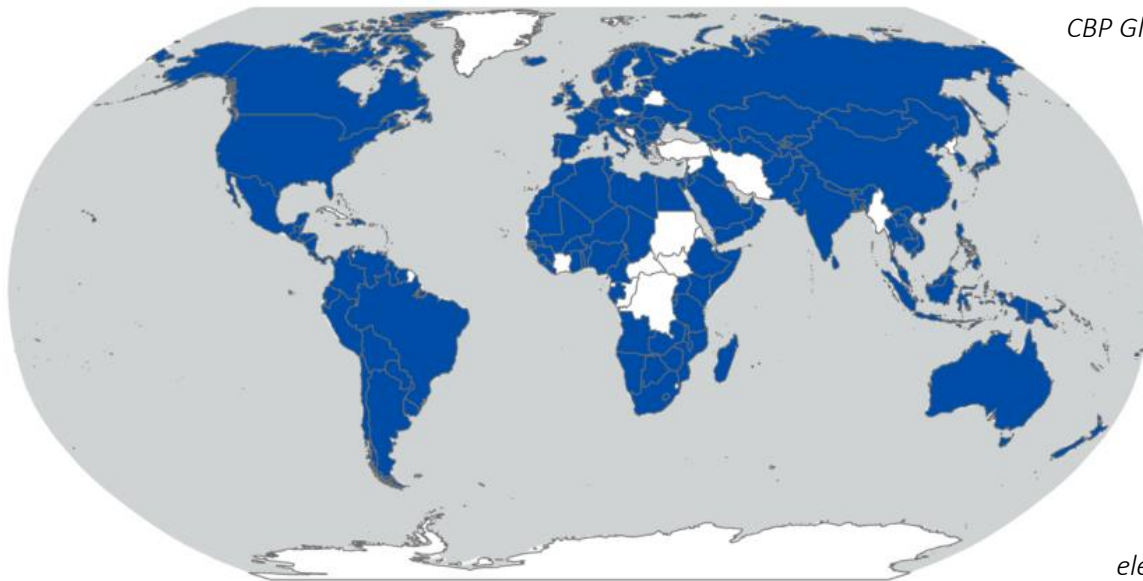


Institution Type Engaged

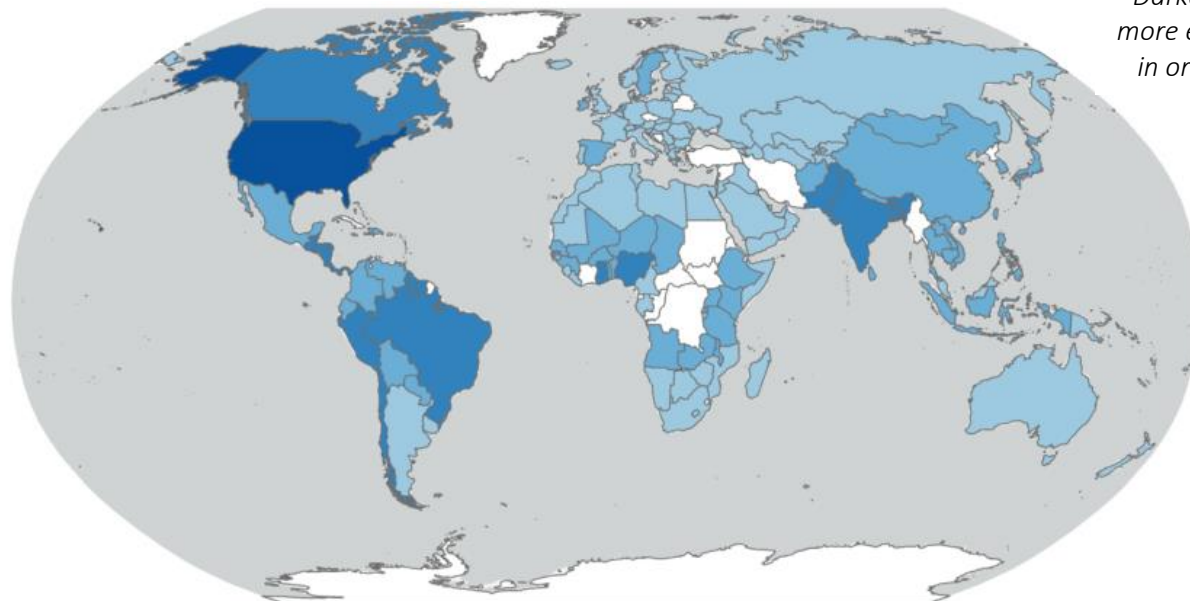


2022 By the Map

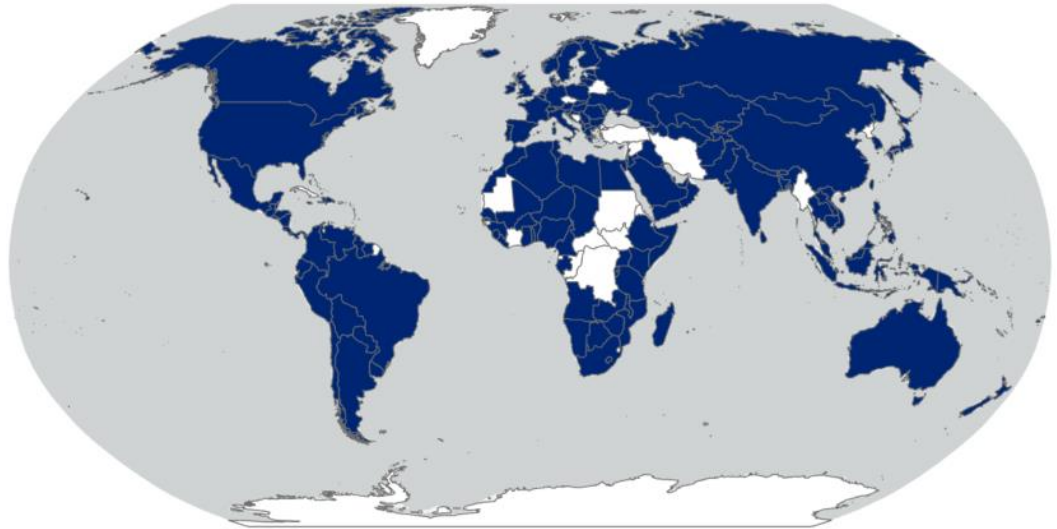
Through international partnerships, outreach, and multilingual offerings, CBP has been able to expand the networks of individuals and institutions aware of, able to access, and able to apply Earth observations. In 2022, CBP activities reached **161** countries, noted in dark blue on the map below. CBP activities also impacted all **50** states and **3** US territories. Each program area impacts different parts of the world in unique ways; for example, SERVIR’s investments harness the capacity of scientists in these states to work in co-development with the hubs. DEVELOP impacts states through hiring and project partnerships.



CBP Global Reach in 2022

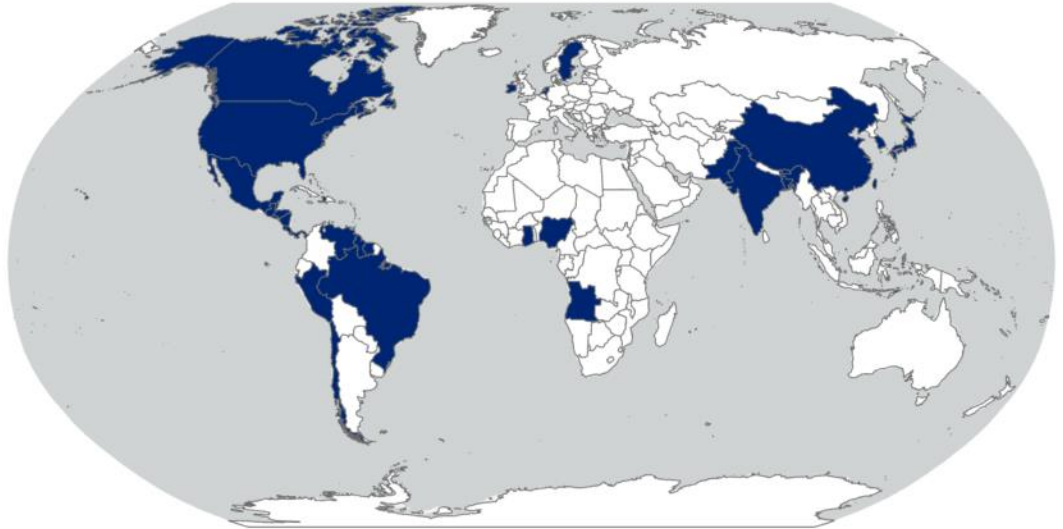


Number of CBP elements reaching each country in 2022. Darker colors denote more elements working in or with a country.



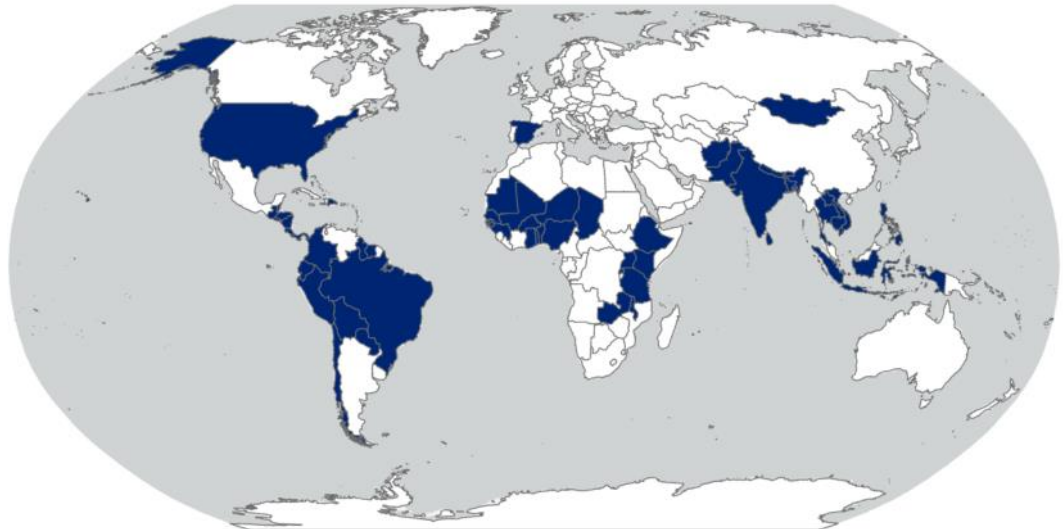
ARSET

159 countries



DEVELOP

33 countries



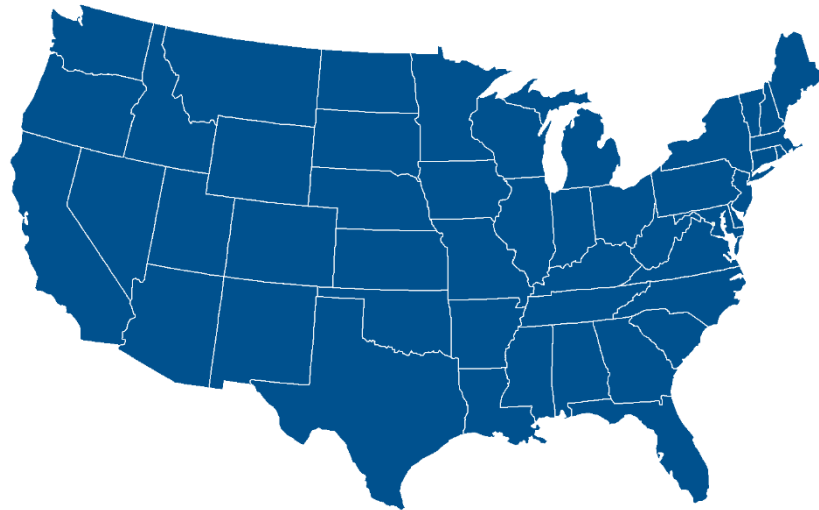
SERVIR

59 countries



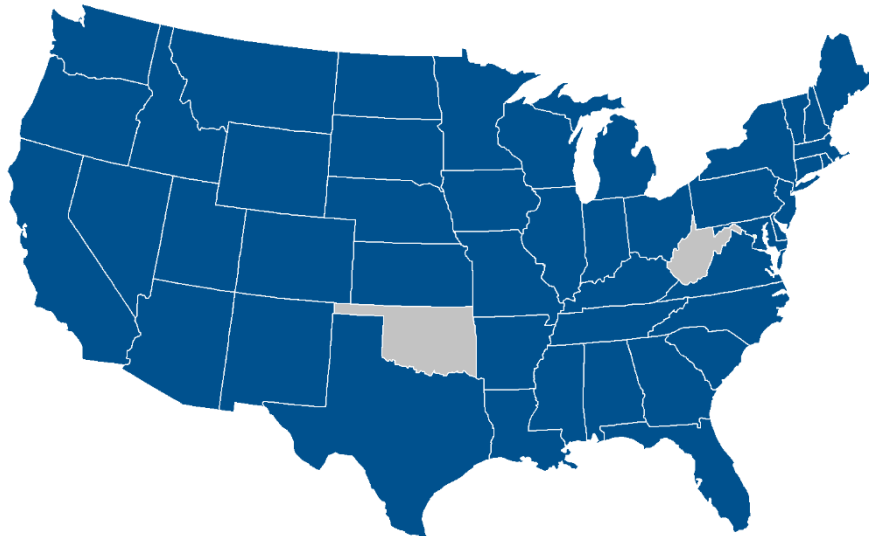
ARSET

50 states



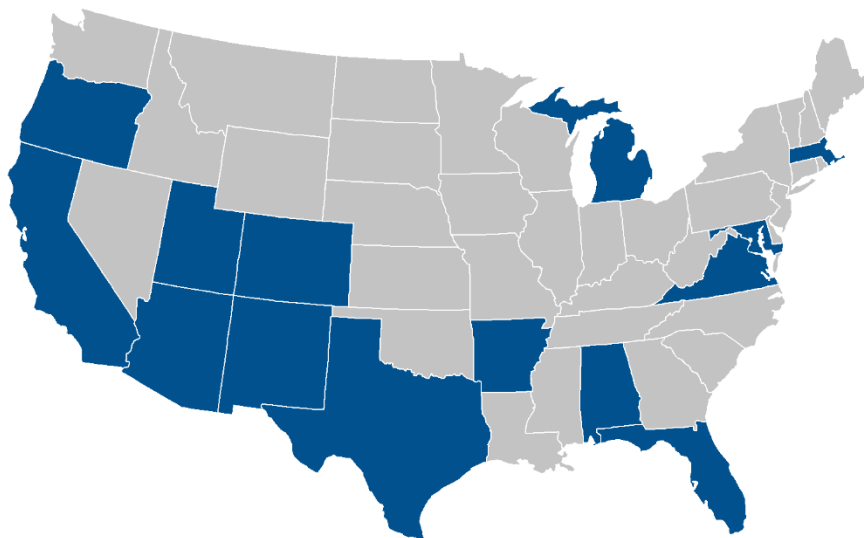
DEVELOP

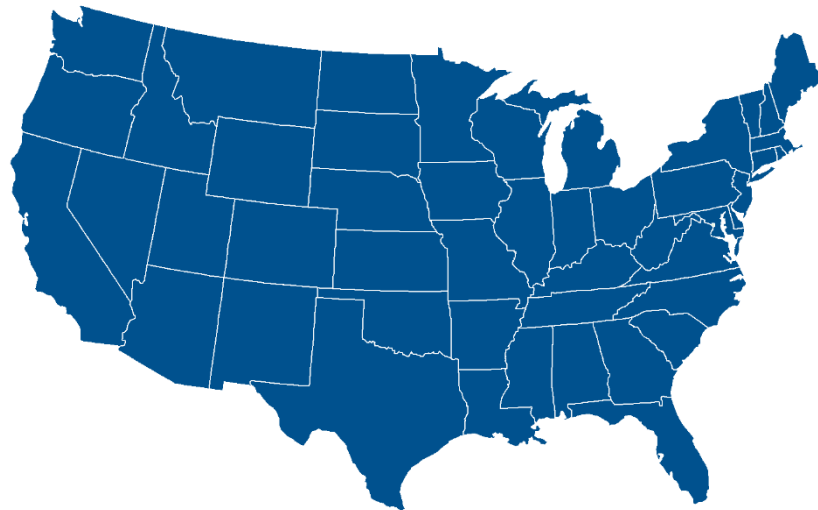
47 states



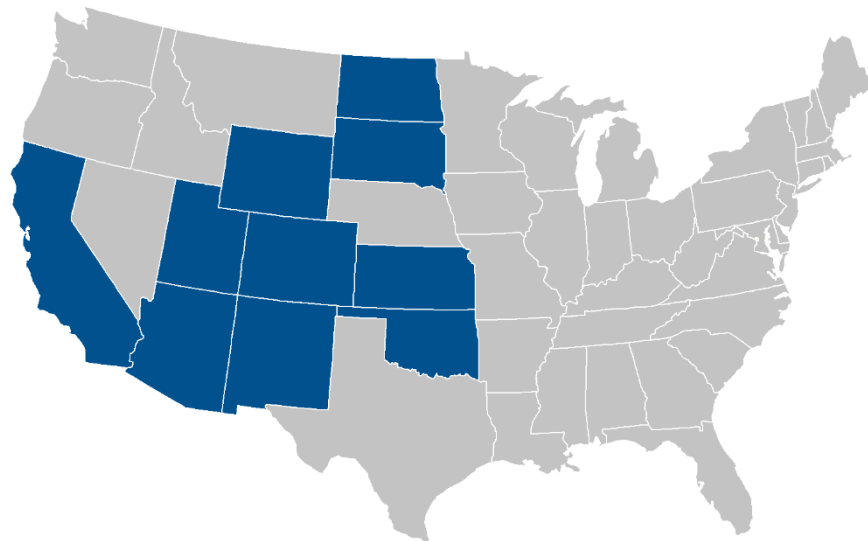
SERVIR

15 states





EEJ
50 states



Indigenous Peoples
11 states

ELEMENT &
PROGRAMMATIC
HIGHLIGHTS



EARTH SCIENCE
APPLIED SCIENCES

ARSET

2022 Overview

Over this past year, ARSET’s instructors produced and delivered 18 new trainings on a wide variety of topics, reaching a total of 21,449 participants in 159 countries. That’s an average of 1.5 multi-session trainings per month! Some brand new topics were covered, including humanitarian applications of remote sensing, evaluating ecosystem services, and a total of 61 guest speakers brought their unique expertise to the trainings. In addition, the team brought on four new team members, three trainers and a training coordinator, and started a Quarterly Newsletter, which features newsworthy items, past and future training opportunities, and highlights of individual participants who have put their training to good use. This year also saw the return of in-person training workshops, with one conducted at the Pecora conference in Denver, Colorado and another, led by the Interagency Water Working Group Science and Applications Team (ISAT), in Argentina.

Highlight Story

Steve Hinton is a Conservation Scientist with the Tulalip Tribes, who are looking to implement a portion of their climate adaptation strategy that involves documenting current natural capital assets in the Snohomish River Basin in Washington State. Steve notes that they hope that using the current environmental conditions as a baseline, they can advocate for changes to local land use laws and management strategies that help to conserve, restore and adapt under changing climate conditions. Steve attended the ARSET Training “Evaluating Ecosystem Services with Remote Sensing” to gain insight into available resources and review case study projects on the topic while the Tulalip Tribes seek funding for this initiative.



*Figure 1. Steve Hinton
Image credit: Steve Hinton*

DEVELOP

2022 Overview

In 2022, DEVELOP navigated a whirlwind of change, growth, and forward momentum. While working together to reopen our DEVELOP offices and bring back in-person projects, the program was able to maintain virtual opportunities through our established Virtual Environmental Justice (VEJ) projects and utilize floating Pop-up Projects (PUP) to conduct projects in exploratory locations. Expanding how we work with project partners, DEVELOP was also able to beta-test new project types, including listening and tech and innovation projects.

In a continued effort to increase outreach and recruitment, DEVELOP ramped up participation in conferences and meetings around the U.S., participating in over 30 events. This engagement highlighted the many applications of Earth observations to address decision making needs. It also highlighted how DEVELOP’s emphasis on participant development is an integral component to how those needs are addressed.



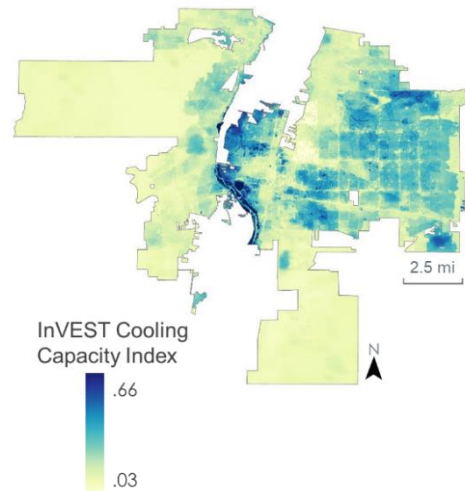
Figure 2. DEVELOP Participants at the American Geophysical Union Fall Meeting in Chicago, Illinois in December 2022.

To cap off the year of change, Mike Ruiz made the difficult decision to retire at the end of December 2022. After 24 years of creating and leading the DEVELOP Program, Mike stepped down as the Program Manager to spend more time with his family. Words can’t express the gratitude and respect the entire program has for his efforts and the commitment to ensure the program continued to successfully move forward the past 24 years. Mike will be greatly missed!

Highlight Stories

Project Highlight

Albuquerque, New Mexico is experiencing increasing urban heat island effects, which impact the community's health, safety, and comfort. DEVELOP partnered with the [City of Albuquerque's](#) Department of Environmental Health, Department of Parks and Recreation, and "Let's Plant Albuquerque!" Using Landsat 8's Thermal Infrared Sensor (TIRS) and the Ecosystem Spaceborne Thermal Radiometer Experiment on the International Space Station (ECOSTRESS), along with the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Cooling and ENVI-Met models, the team modeled tree cover interventions and created land surface temperature maps. These results communicate to project partners how an increased canopy can mitigate urban heat and assist the city to make data-driven decisions for their tree planting goal. The city is sharing the DEVELOP results online alongside its Climate Action Plan to support cooling interventions.



Event Highlight

After two years, DEVELOP participants returned to NASA Headquarters to showcase the summer projects during 2022 Earth Science Applications Week! 'DEVELOP Day' was held on August 8th and featured 27 project posters, 8 flash talks, a DEVELOP alumni panel, and a panel of summer partners from the USDA Natural Resources Conservation Service, Eastern Shore Land Conservancy, and the Chilean Embassy. Additionally, participants presented 14 projects virtually throughout the week, including a highlight on DEVELOP's partnership with the



National Park Service (NPS).

SERVIR

2022 Overview

During 2022, the SERVIR Science Coordination Office (SCO) continued to provide science and technical support and coordination across the SERVIR network. This was the third and final year for the SERVIR Applied Sciences Team (AST) selected through the ROSES 2018 solicitation, and a new SERVIR Applied Sciences Team was announced, selected through the ROSES 2021 solicitation to begin activities in January of 2023. SERVIR West Africa began Phase II activities, implemented on March 15 and with the official launch ceremony for its second 5-year phase held November 1 as part of GEO Week 2022 / AfriGEO Symposium events in Accra, Ghana. SERVIR Mekong ended Phase I activities at the end of the fiscal year, with the launch of Phase II for the hub, now renamed as SERVIR Southeast Asia (SEA), planned for January 24, 2023. The SERVIR network continued to embrace new opportunities and ongoing initiatives in 2022, including the SERVIR Eastern & Southern Africa Gender-sensitive Agricultural Index-based INSurance (GAIINS) stakeholder engagement workshop in Kenya in June, NASA Asia-AQ Project team meetings in Thailand in July, and SCO participation in the Forest Data Partnership Meeting in Washington, DC in August, and in the NASA and the Environment Symposium in September.

Highlight Stories

In January of 2022, the Government of Malawi used a [Community-Based Flood Early Warning System \(CBFEWS\)](#)—designed in part by teams from two SERVIR hubs—to warn communities of flooding around the Phalombe River.

CBFEWS pairs ground observation with satellite data from the GEO Global Water Sustainability (GEOGloWS) initiative to provide up to 15-day flood forecasts. It integrates the GEOGloWS streamflow forecasting service, which was co-developed with SERVIR Applied Sciences Team PI Dr. Jim Nelson. Funded and implemented by the UN Development Programme (UNDP) and other regional partners. The service was designed with expertise from SERVIR’s Eastern and Southern Africa and Hindu Kush-Himalaya hubs—the latter having previously designed CBFEWS programs in Nepal. Fedson Chikuse, Deputy Director of Malawi’s Department of



Figure 5. Community-based flood early warning systems (CBFEWS) use stream gauges (like the one pictured above) and satellite precipitation data to provide timely warnings to nearby communities (Image Credit: ICIMOD)

Disaster Management Affairs says the success of this effort “will save lives and property in these flood-prone areas” when the next major flood occurs.



Figure 6. A community in southern Malawi installs an alarm unit for disseminating flood early warnings.

In November, Samuel Gama, Principal Mitigation Officer of Malawi’s Department of Disaster Management Affairs, announced that the SERVIR-supported flood warning system saved the country \$40 million in 2022. Ahead of two major cyclones earlier this year, Malawi’s government used the CBFWS to warn people and prevent loss of life and property.

Indigenous Peoples Initiative

2022 Overview

IPI is dedicated to building lasting relationships with Indigenous communities by creating a trusted, reliable, and Indigenous-centric geospatial community with a focus on environmental justice and climate issues on Indigenous lands and territories. This year, the team focused efforts on growth and strategic planning, while remaining committed to core objectives of capacity building. The IPI team hired two new members, Nikki Tulley (Navajo Nation) and Sativa Cruz (Ohkay Owingeh), held their first Annual Retreat, and drafted a 5-year strategic plan. Simultaneously, the team conducted four remote sensing trainings in support of the Tribal GIS Conference, with the Karuk Tribe Natural Resources Department, at the National Tribal & Indigenous Climate Conference, and at the Indigenous Mapping Workshop. The team also provided multiple presentations to increase outreach and engagement at workshops and conferences such as the 2022 National Forum on Earth Observation and Geo for Good. The IPI team continued collaborations across CBP and NASA through retreats, program reviews, Needs Assessments, Early Adopters initiatives, NASA Nation-to-Nation Tribal Consultation, Employee Research Group discussions, and the Transform to Open Science (TOPS) team activities. The team also committed to supporting Equity and Environmental Justice (EEJ) activities, with Nikki Tulley filling the role as an Associate Program Manager, and to Diversity, Equity, Inclusion, and Accessibility (DEIA) with hosting two Native interns. As the IPI team looks forward, they are committed to ensuring sustained programmatic support for long lasting impacts within Indigenous communities and NASA.

Highlight Story

The Indigenous Mapping Workshop (IMW) has provided training on several geographical information system (GIS) tools including Google Earth, Esri ArcGIS and computer coding. In the hands of Indigenous Peoples, these can be powerful tools in the preservation and promotion of Indigenous land stewardship practices. The Vancouver-based Firelight Group has organized the Workshops since 2014.

For IMW 2022, NASA's IPI and the Canadian Space Agency (CSA) delivered an introductory session on satellite EO with optical and radar imagery and organized two dialogue sessions with industry and academia colleagues and their Indigenous project partners. In a yarning session on "Collective Turtle Island Storytelling and EO" participants shared their EO stories. Additionally, IPI delivered two sessions with Esri Canada on wildfires.

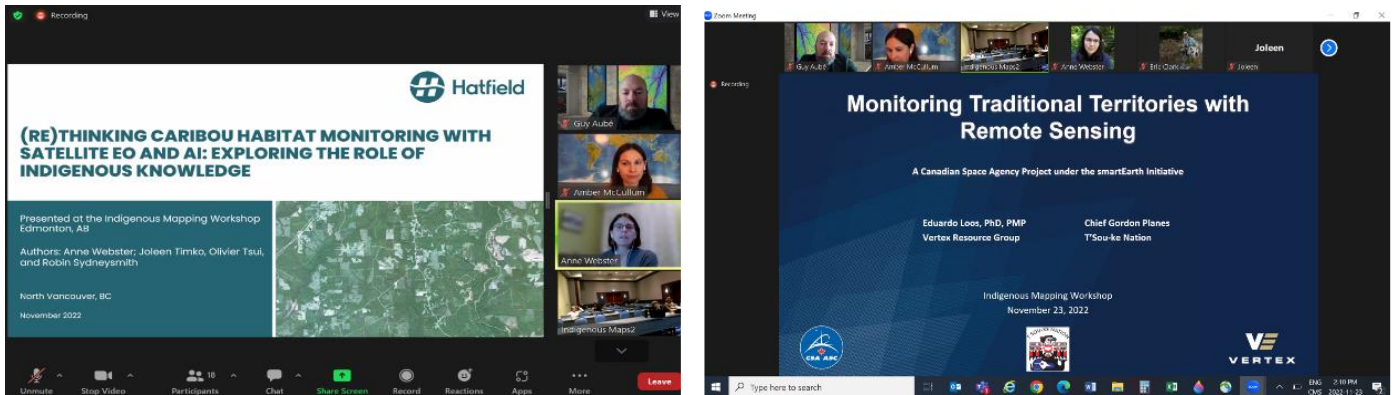


Figure 7 and 8. The Indigenous Mapping Workshop 2022 garnered international participation in a hybrid format.

The NASA IPI and CSA IMW 2022 sessions also represented a delivery under the international Committee on Earth Observation Satellites, CEOS TASK CB-22-05. It was entitled “CSA-NASA Indigenous Mapping & Training Workshop 2022.” NASA and CSA contributed this deliverable to the CEOS Working Group on Capacity Building and Data Democracy (WGCapD) annual work plan.

Apart from the introductory session on the basics of satellite remote sensing, each of the jointly led NASA-CSA sessions included ample opportunities for participants for discussion and dialogue. The team carried over two important lessons learned from their participation in IMW 2021: the principle of “two-way learning”, and the premise that “dialogue is a result” of our engagement in the Workshop. The IMW 2022 offered a welcome opportunity to continue the dialogue between the Indigenous mapping community, and NASA and CSA.

In practical terms, the chat-feature of the Zoom online format and the helpful onsite support by a Firelight technical person enabled everybody to communicate their ideas and thoughts. The discussion highlighted the importance of:

- engaging and involving the youth in future activities
- developing EO capacities and activities at local or regional scales
- committing toward longer-term EO and Indigenous capacity development
- recognizing and acknowledging multiple ways of knowing, in particular Indigenous knowledge systems
- co-development and co-design processes for EO products, tools, and projects.

Prizes & Challenges

2022 Overview

In 2022, P&C continued to celebrate NASA’s long history of open innovation by inviting the public to participate in incentivized competitions called prizes and challenges. The program developed and executed 3 prize competitions: NASA Airathon: Predict Air Quality (pg. 21), NASA Earth Science in Action Comic Strip Contest, and the Tick Tick Bloom: Harmful Algal Bloom Detection Challenge (pg. 27). P&C also developed two new crowdsourcing projects to leverage the power of open innovation for societal benefit using NASA’s EO: the Women’s Aqua Boost Project and the Data Center Energy Solutions Project.

Members of the P&C area led [NASA’s engagement](#) at the 2022 Smithsonian Folklife Festival, producing NASA Day on July 2, 2022. The festival theme was Earth optimism – finding hope in the face of odds that might seem overwhelming – with agency members bringing climate, sustainable agriculture, and Earth science to attendees through storytelling, videos, food demonstrations, and hands-on citizen science opportunities. Attendees participated in activities at the People Powered Science tent to become a citizen scientist through [The GLOBE Program](#) and learn about NASA missions including [Landsat](#), [ICESat-2](#), and [GPM](#). Participants also heard stories from NASA researchers and managers about how NASA supports Earth science applications including natural resources management. To satisfy any pangs of hunger, they saw cooking demonstrations at Festival Foodways and learned about how NASA supports sustainable fish farming and water management in the Chesapeake Bay. The team received a NASA Agency Honor Award for this effort.



Figure 9. Images from NASA Day at the 2022 Smithsonian Folklife Festival

Highlight Story

P&C supported Applications Teams of the Multi-Angle Imager for Aerosols (MAIA) and Tropospheric Emissions: Monitoring of Pollution (TEMPO) in leading [The NASA Airathon: Predict Air Quality Challenge](#), a prize competition inviting participants to use NASA satellite data, model outputs, and ground measurements to develop algorithms for estimating daily levels of surface-level air pollutants with high spatial resolution. The challenge, developed with collaboration from the U.S. Department of State, U.S. Environmental Protection Agency, and crowdsourcing platforms DrivenData and HeroX, focused on two critical air quality measures: [PM2.5](#) and [NO₂](#) in urban areas surrounding the cities of Los Angeles (the U.S.), Delhi (India), and Taipei (Taiwan).

This challenge generated over 1,250 submissions and drew more than 1,000 participants from 123 countries and [winners](#) from the US, India, Kenya, Kazakhstan, and the Netherlands. Interestingly, only one of the five winners self-identified as having expertise related to air quality, demonstrating the value of engaging out-of-discipline experts in NASA’s scientific and technological missions.

Particulate (PM2.5) Track Winners



1st Place - Vishwas Chepuri, Nalgonda, India



2nd Place - Raphael Kiminya, Meru, Kenya



3rd Place - Kudaibergen Abutalip, Nur-Sultan, Kazakhstan



MAIA (top) and TEMPO (bottom)
 Images from mission websites:
<https://maia.ipl.nasa.gov/>
<http://tempo.si.edu/>

Trace Gas (NO₂) Track Winners



1st Place - A. David Lander, United States



2nd Place - Raphael Kiminya, Meru, Kenya



3rd Place, Sukanta Basu, Delft, The Netherlands



Figure 11. (left) Winners of the PM_{2.5} and NO₂ tracks in the NASA Airathon: Predict Air Quality Challenge; (right) Renderings of MAIA and TEMPO missions.

Analyses of submissions including the winning solutions in both tracks demonstrate that:

1. Incorporating information from multiple models improves results, as compared to using a single model to generate surface level air pollutant estimates.

2. Data gaps from current satellite products have negative impacts on model accuracy. These gaps may be addressed in the future as TEMPO and MAIA missions' higher resolution data become available.
3. Implementation of these models is feasible on most computing environments, owing to the low computational cost and memory requirements of winning models – thereby making possible the dissemination of air quality information to the public in a timely manner.

Open-source code and documents from all winning models are on [DrivenData's repository on GitHub](#). MAIA and TEMPO teams plan to further analyze and apply challenge results as they generate technical resources and air-quality products for their data communities. Furthermore, the U.S. Department of State has interest in evaluating and using methods from the winning models through an ongoing NASA Health and Air Quality project and to provide useful air quality information to State Department employees and the public at various embassy locations.

Equity and Environmental Justice

2022 Overview

After laying the groundwork in 2021, the Equity and Environmental Justice element began activities in earnest in 2022 with the competition of a ROSES solicitation that resulted in 39 grant-funded projects. This portfolio includes landscape analyses, feasibility studies, and data integration studies, and covers a wide variety of thematic areas such as urban heat, flooding, and wildfires. Each of these projects utilizes NASA Earth observations and works in partnership with an environmental justice community organization to ensure the benefits of these projects are delivered directly to the communities they work with. The element also welcomed five associate program managers and a program manager on detail from Wallops Flight Facility, R. Owen Hooks. The team hosted a Town Hall at the AGU Fall Meeting to build connections with the environmental justice research community.

Highlight Story

The return of in-person conferences and meetings opens the door on new partnerships, providing the opportunity to connect over science and the communities impacted by this work. At the 2022 AGU Fall Meeting in Chicago, Illinois, members of the EEJ team took this opportunity to engage with the scientific community and environmental justice practitioners in Chicago.

The AGU fall meeting was an early opportunity to share the team’s work, gather feedback from other scientists, and connect with local EJ leaders in Chicago. Early in the week, the team presented NASA’s EJ work during a technical session entitled “Geospatial Data Applications for Environmental Justice” and organized a town hall to convene members of the scientific EJ community at AGU.

Later in the week, the team had the opportunity to connect with EJ leaders in Chicago at Discovery Partners Institute, where they were hosted by one of the Equity and Environmental Justice Principal Investigators (PIs), Dr. Ashish Sharma. The meeting convened representatives from EPA Region 5, local mayors associations such as the South



Figure 12. Environmental Justice leaders in Chicago met with NASA team members and the science team behind e-JUST, a scalable urban toolkit for Environmental Justice in Dec. 2022

Suburban Mayors and Managers Association and the Metropolitan Mayors Caucus, local non-profits such as the Friends of the Chicago River and the Walder Foundation, the City of Chicago Health Department and local mayors, in addition the representatives from the scientific project team and NASA.

Over the next two years, Dr. Sharma’s team will develop a scalable, GIS-based urban toolkit on the web for EJ leaders in the region called e-JUST to co-identify extreme heat and air quality threats to health, equity, and crime to improve inputs into urban decision-making.



Figure 13 and 14. (left) Dr. Ashish Sharma, PI of the e-JUST project, shared air quality monitoring tools and techniques with the NASA team. (right) The EJ program area hosted a Town Hall at the AGU Fall meeting with presentations from the Indigenous Peoples Initiative, the Transform to Open Science team, and the Health and Air Quality Applied Sciences Tiger Team, Satellite Data for Environmental Justice.

FOCAL POINTS



Diversity, Equity, Inclusion, and Accessibility

Diversity, Equity, Inclusion, and Accessibility (DEIA) reflects NASA’s core value of inclusion and is an integral part of CBP’s work and daily operations. Members of the CBP team are members of numerous DEIA working groups and organizations at NASA and beyond, and each element supports DEIA work in varied ways.

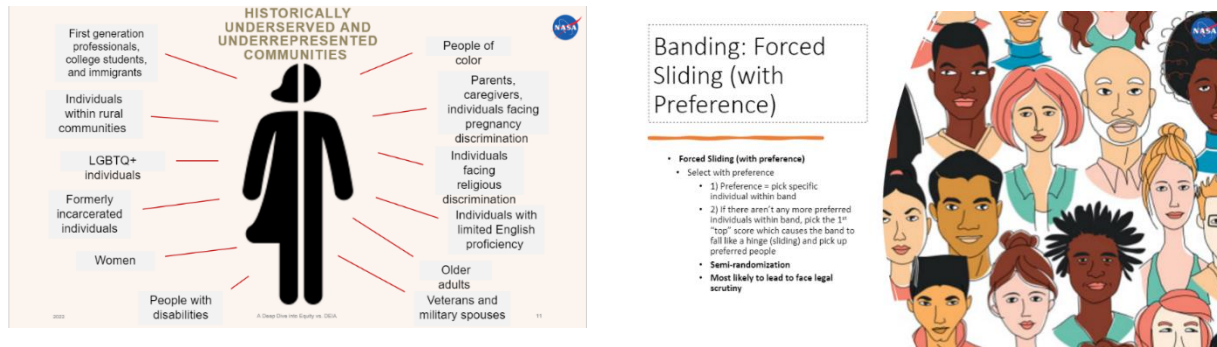


Figure 15. Presentations created by DEIA intern Cara Crosby.

In 2022, CBP was fortunate to support the work of a DEIA intern, Cara Crosby. Cara supported the Applied Sciences DEIA Working Group and delivered numerous presentations and conversations on topics such as Work Life Balance and Intersectionality.

The Indigenous Peoples Initiative mentored two Native interns through the Minority University Research and Education Project American Indian and Alaska Native Science, Technology, Engineering, and Math Engagement (MAIANSE) program and the Northern Arizona University Water and Land Internship. The team also onboarded two Indigenous Earth Science Researchers at the beginning of the year, further contributing to a diverse internal team and NASA workforce. Each year, DEVELOP analyzes demographic data from voluntary self-identification information provided by participants to track applicant diversity. DEVELOP will continue to track demographic data in the coming year to support inclusive recruiting efforts and diverse teams of scientists.

To be accessible to a broad audience, ARSET offered 8 bilingual trainings (English and Spanish), and one trilingual (English, Spanish, and French) training in 2022. They also offer all training recordings and materials on the website for on-demand viewing for those who might not have the internet bandwidth to participate live. This year, in response to NASA’s Equity Action Plan, the team began a working group to strategize outreach and training development for underserved communities and participated in the NASA Equity Action Plan Town Hall.

P&C strived to include diverse audiences and provide equitable, inclusive experiences for participants in various open innovation projects. The NASA Earth Science in Action Comic Strip Contest is a prime example where DEIA values were part of the goals: (1) to engage artist participants of varying ages, genders, ethnicities, and socio-

economic backgrounds to use creative storytelling to produce artwork that makes clear the data science story, while (2) engaging and inspiring current and new artwork viewing audiences of diverse backgrounds, sparking public interest in NASA Earth Sciences Applied Sciences Program activities; and where DEIA values drove intentional actions throughout the lifecycle of the project. Competition outreach included developing assets, e.g., flyers, in English and Spanish, and invitations to arts and science programs at Historically Black Colleges and Universities, Tribal Colleges, Hispanic Serving Institutions, Asian American and Pacific Islander Serving Institutions, and Agencies focused on specific populations, including women and girls, rural facing organizations, and deaf communities. The Finalist Judging Panel was intentionally formed to include artists and NASA experts from diverse genders and races, and with diverse artistic styles.

108 artists from 14 countries, including the United States, India, Egypt, Canada, Russian Federation, Argentina, Mexico, United Kingdom, Peru, Columbia, Guatemala, and Pakistan participated in the contest. A post-competition survey of participants was conducted by SciArt Exchange, with an 18% response rate. Participants self-identified belonging to a diverse group of races; over 70% of respondents identified as female; and one artist indicated that they were living with a serious disability.



SciArt EXCHANGE
NASA EARTH SCIENCE IN ACTION
COMIC STRIP CONTEST

INSPIRANDO AL MUNDO A TRAVÉS DE CÓMICS
MUESTRA CÓMO LAS CIENCIAS DE LA NASA BENEFICIAN LA VIDA EN LA TIERRA!

QUÉ
SELECCIONA UNA DE TRES HISTORIAS SOBRE CÓMO LOS DATOS SATELITALES DE LA NASA DE LAS CIENCIAS DE LA TIERRA, AYUDAN A LAS COMUNIDADES CON SUS DESAFÍOS AMBIENTALES Y CREA CÓMICS DIGITALES O DIBUJADOS A MANO!

POR QUÉ
LAS OBRAS GANADORAS RECIBIRÁN VISIBILIDAD. INSPIRA Y EDUCA SOBRE LOS DESAFÍOS AMBIENTALES!

LOS GANADORES TAMBIÉN RECIBIRÁN UN TROFEO Y UN CERTIFICADO!

QUIÉN
JÓVENES (14-18 AÑOS)
ADULTOS (MAYORES DE 18 AÑOS)
ABIERTO MUNDIALMENTE

CUÁNDO
LA FECHA LÍMITE PARA LOS TRABAJOS EN LÍNEA SERÁ EL 13 DE AGOSTO DEL 2022, 11:50 EE. UU. CT.

DÓNDE
O VISITA
[BIT.LY/SAEINACTION](https://bit.ly/saeinaction)

ESCANÉAME

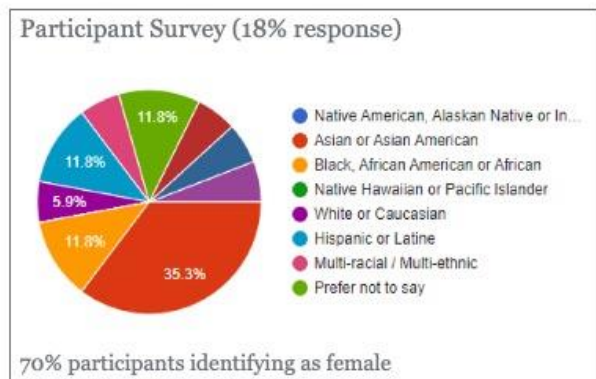


Figure 16. (clockwise from left) NASA Earth Science in Action Comic Strip Contest announcement flyer in Spanish; Finalist Judging Panel including (clockwise from top left) Geneva Bowers, Jim Toomey, Hyesu Lee, Nicole Stott, Lawrence Friedl, Mostafa Moussa, Nathan Fox, and Kristin Laidre; Participant demographics based on post-competition submission participant voluntary self-identification survey.

The SERVIR SCO supported NASA Headquarters to develop the agency Gender Equity and Equality Plan Update for the White House Gender Policy Council. SERVIR continued its partnership with Arizona State University through the ‘training of trainers’ workshop ‘Advancing Women’s Prosperity in the Workplace,’ aimed at engaging early career women to improve access, increase agency, and pursue pathways for economic opportunity in Asia, Africa, and Latin America, which took place May 16 -20, and hosted 23 women from STEM fields across 19 institutions from five countries in the Amazonia region. SERVIR began implementation work on a Gender-sensitive Agricultural Index-based INSurance (GAIINS) award from the Office of Gender Equality and Women’s Empowerment of USAID with a stakeholder workshop held in Naivasha, Kenya, and continued to partner with Advancing Gender in the Environment (AGENT) in finalizing a gender analysis tool (designed to empower the hubs to conduct gender-responsive service design) to be launched February 15, 2023.

The Equity and Environmental Justice solicitation through ROSES-21 piloted the incorporation of inclusion plans as a part of the selection process. Each submission required a two-page inclusion plan to describe how the project team will foster an atmosphere of inclusion across many diversity characteristics, such as career stage, disability, ethnicity, gender, race, geography, and sexual orientation. The inclusion plans did *not* factor into the overall adjectival rating of the proposals, but they were evaluated by an independent panel composed of DEIA experts and scientists that are active in DEIA activities.

Transform to Open Science

2023 was named a “[Year of Open Science](#)” by NASA and 10 other federal agencies, 85 universities, and other organizations. CBP is committed to open science principles and initiatives, and got a head start on this transformation in 2022. Open science requires a culture shift to a more inclusive, transparent, and collaborative scientific process, which will increase the pace and quality of scientific progress, and CBP hopes to be a leader in this space by building awareness, skills and by using open source science principles. Open science also has the potential to lower barriers to entry for historically excluded communities, help scientists understand how people utilize NASA data and code, and increase opportunities for collaboration while promoting scientific innovation, transparency, and reproducibility.

In 2022, SERVIR continued to develop methods and strengthen capacity for using open-source Earth observation data to address local challenges in climate change, food security, water and related disasters, land use, and air quality. A training webinar with the Central American Integration System (SICA) was held January 21, 2022, with support from Coordination Centre for the Prevention of Natural Disasters in Central America (CEPRENAC), Planet, United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), World Conservation Society (WCS), CEOS WGCapD, NASA Disasters Program, and the AmeriGEO Disasters Working Group. The training introduced over 260 participants to the Planet / Norway's International Climate & Forests Initiative (NICFI) mosaic data. Other activities included Geo for Good events, including two presentations in the Geo for Good Lightning Talks Series, and participation in the Geo for Good Summit October 4 – 6, with the SERVIR team providing a session/training on 'Capacity building with SERVIR's services on HYDrologic Remote Sensing Analysis for Floods (HYDRAFloods)'. The SCO Geospatial Information Technology (GIT) team developed a "SOCRATES and Beyond" compute cluster strategy for supporting the SERVIR network's compute needs for the next 5 years. continues to host several high-value datasets in various delivery formats and services using enterprise systems such as Esri's ArcGIS Server, Unidata's Thredds Data Server, and the Open Geospatial Consortium's GeoServer, to strengthen the availability of open-source EO data.

DEVELOP continued to host Software Carpentry lessons each term to train participants in Unix Shell, Git, and Introductory and Intermediate Python or R Language. The program also offered Google Earth Engine lessons based on ecological remote sensing modules developed by Colorado State University. DEVELOP Fellows were joined by trained Software Carpentry instructors and helpers who facilitated live coding workshops that included instructional tutorials, hands on exercises, and troubleshooting and support as needed. Participants enter DEVELOP with a variety of technical skills, and these lessons—as part of DEVELOP's capacity-building framework—continue to give participants opportunities to build and improve technical skills, which they can apply in DEVELOP projects and beyond. In total, 408 participants, 19 instructors, and 35 helpers took part in coding workshops through DEVELOP in 2022.

On April 25, the IPI, the Earth Science Data Systems (ESDS) Program, the Earth Science Data Systems GIS Team ([EGIST](#)) and the [Transform to Open Science](#) (TOPS) teams came together to provide a hands-on workshop titled: *From Earth Observations to Action: NASA data for natural resource monitoring and climate change* for the 12th annual Tribal GIS Conference in Albuquerque, NM. This year's conference theme was [Geospatial Resilience in Indian Country](#). This workshop introduced participants to the application of NASA remote sensing data and tools to monitor a variety of natural resource and climate change indicators, highlighting droughts and wildfires.

The IPI team also facilitated a listening session titled: *Open Science, Open Ears*, focusing on input about NASA’s TOPS initiative and suggestions to improve tribal engagement. The team interacted directly with 28 participants from 13 states representing various tribal nations, such as the Pit River Tribe, the Hualapai Tribe, the Pueblo of Tesuque, the Salamatof Tribe, and others. Participants came from a variety of backgrounds including tribal natural resource managers, students, federal agency employees, and more.

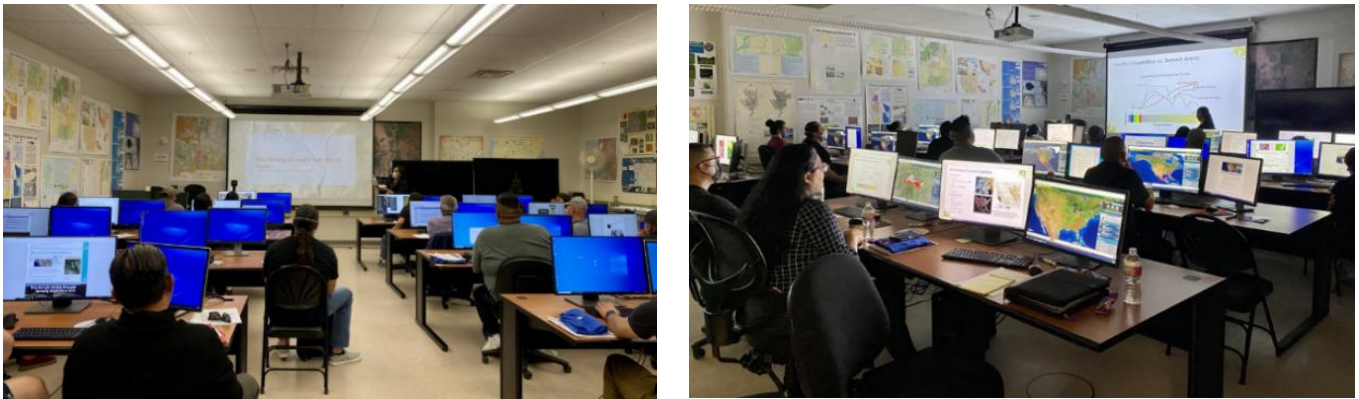


Figure 17 and 18. Members of the IPI team conducting trainings and listening sessions.

To make our training materials as accessible as possible to a worldwide audience, ARSET relies strictly on open-source software for any processing or analysis. This ensures that participants can replicate the methodologies regardless of what software they have access to. Three of the most popular open-source softwares in recent ARSET trainings are QGIS, Google Colab, and Google Earth Engine (GEE). Google Earth Engine was featured in four trainings in 2022. ARSET continues to work with data providers to ensure they are training on the most up-to-date methods of data access. ARSET also offers synchronous and asynchronous training options for those who may have limited access to the internet.

Global Networks

CBP continued to be highly engaged in global networks such as the Committee on Earth Observation Satellites (CEOS) Working Group on Capacity Building and Data Democracy (WGCapD), the Group on Earth Observations (GEO), and the Earth Observation Training, Education, and Capacity Development Network (EOTEC DevNet), where CBP provides significant leadership and secretariat support.

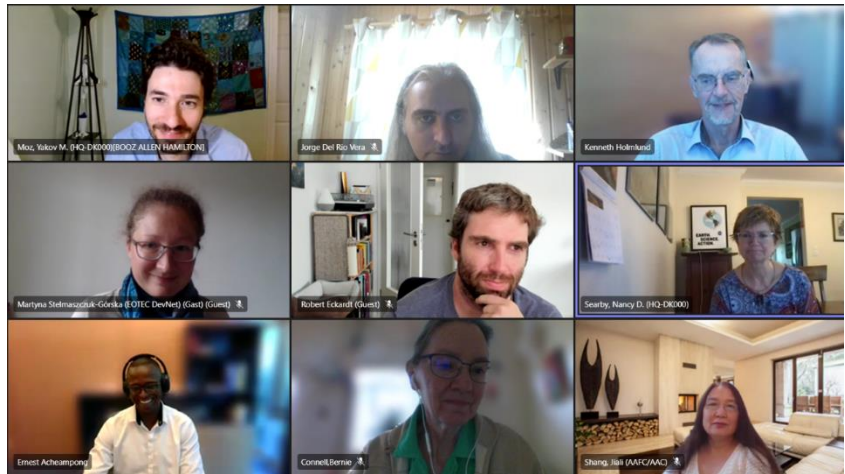
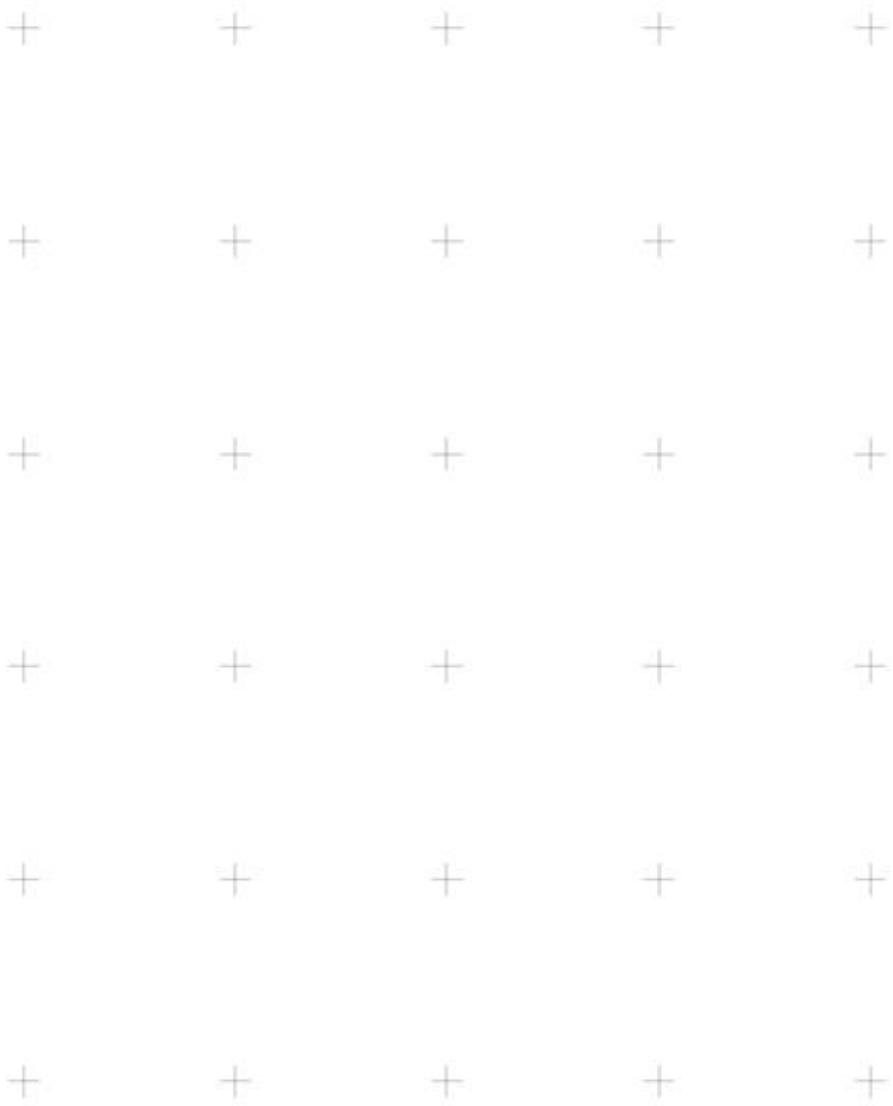


Figure 19. Members of the EOTEC DevNet secretariat and leadership team meet virtually in 2022.

CBP participated in numerous GEO events throughout the year, including in-person meetings across the globe. Members of the CBP community attended the GEO Symposium, AmeriGEO week, AfriGEO Week, the AOGEO Symposium, and the Global Forest Observations Initiative Exchange, to name a few. Members of the CBP team also co-created and promoted training activities, projects, and services related to the GEO flagships and initiatives.

After transitioning the role of CEOS WGCapD chair to UNOOSA in 2021, NASA remained an active participant in the working group, completing 15 deliverables in 2022. These deliverables included trainings for the Indigenous Mapping Workshop in partnership with the Canadian Space Agency (CSA), a webinar on satellite remote sensing of urban heat islands between NASA, NOAA, and ESA, and a 10-week feasibility study related to data cube algorithm creation with CRECTEALC.

Since its inception two years ago, EOTEC DevNet has grown from a concept to a functional network connecting member organizations and delivering products and services of value to its target audience. Its core activities include hosting regional working group and task team meetings throughout the year, developing innovative products such as a [flood tools tracker](#) to advance discoverability of EO tools, and supporting the engagement of emerging space agencies in regional and global networks. EOTEC DevNet initiated fruitful new partnerships in 2022 with organizations such as [EO College](#) and the [EO4GEO Alliance](#).



IMPACT STORIES



Inter-agency Needs Assessment Collaboration for use of EO with the Navajo Nation

As part of an inter-agency collaboration focused on developing outreach to Indigenous communities for capacity building activities around EO, the IP initiative has partnered with several agencies to develop a community event titled, *Nihimá Nahasdzáán: the Art of Mother Earth*, on the Navajo Nation. The IPI, USGS, Ladies of Landsat, and America View have partnered and are planning the event for April 2023. Throughout fall 2022 the team developed an EO app powered by Google Earth Engine (GEE), hosted a youth event headed by America View, and finalized plans for the main community event to be held in 2023. The purpose of the Navajo Nation EO event is to increase awareness of the data available for community access, as well as develop a better understanding of the EO needs in the community.

Nikki Tulley was invited to attend the 2022 Geo for Good Summit and give an afternoon plenary community talk titled, *Drought Severity Evaluation Tool: A collaboration of Sovereignty and Science for the Navajo Nation*, which has been matured from an initial DEVELOP project by NASA’s Western Water Applications Office. She also participated in a panel at Geo for Good with the Ladies of Landsat titled *An Inclusive Future for the Geo for Good Community*. On the last day of the summit, Nikki and team held a session with summit attendees to discuss development of a GEE EO app. The GEE EO app is being developed for the Nihimá Nahasdzáán event to help new EO users visualize Landsat imagery on the go via desktop or mobile devices.

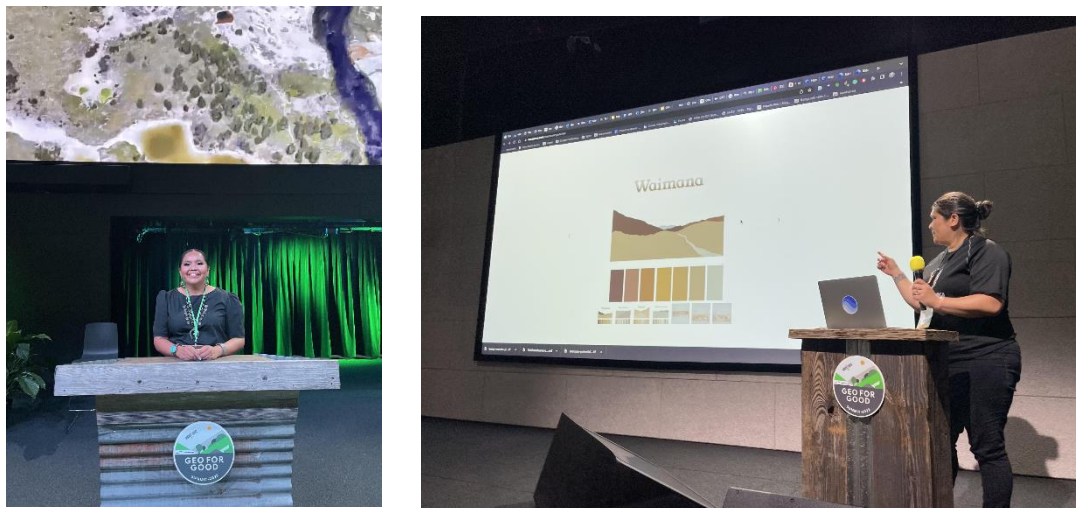


Figure 20 and 21. (left) Nikki Tulley at the Geo for Good afternoon plenary talk (right) Geo for Good Navajo Nation Event Google Earth Engine app development session.

Most recently, a sub event was held at the Chil Chi Tah Community School leading to the main Navajo Nation EO. This event was headed by America View in December 2022, where the team introduced students to STEM EO activities. Nikki participated in this event and discussed her role at NASA, and most specifically shared about

capacity building development for EO opportunities in Indigenous communities. This community event increased interest in the main EO event to be held in April 2023.

Bangladesh Launches High-Impact Weather Assessment Tool

On March 30, 2022, the Bangladesh Meteorological Department officially launched SERVIR’s High Impact Weather Assessment Toolkit (HIWAT) and adopted it as part of their daily operations. Developed through a SERVIR Applied Sciences Team project, HIWAT leverages GPM and numerical forecasts to provide Bangladeshi authorities with reliable 48-hour outlooks for heavy precipitation, high winds, lightning, and other hazards. The Government of Bangladesh funded a high-performance computing system to make HIWAT part of their long-term operations.



Figure 22. BMD and SERVIR-Hindu Kush Himalaya leadership at the HIWAT launch event in Dhaka, Bangladesh on March 30, 2022. HIWAT enhances BMD’s capacity to model extreme weather hazards and issue operational forecasts.

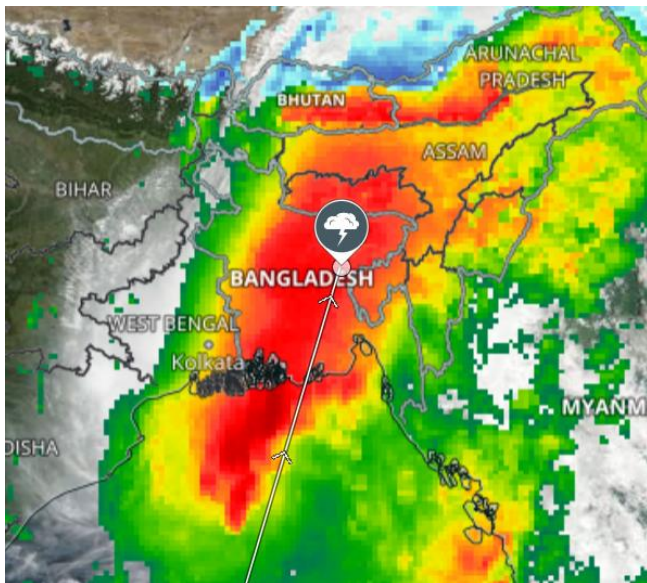


Figure 23. Cyclone Sitrang dropped up to 13 inches of rain on parts of central Bangladesh in October (Image: NASA Worldview)

On October 24, the Bangladesh Meteorological Department used HIWAT to guide its response to Cyclone Sitrang, providing detailed predictions of heavy precipitation prior to landfall. HIWAT was customized for Bangladesh and had been running at the Bangladesh Meteorological Department since March. According to meteorologist Dr. Abdul Mannan, “HIWAT was capable to simulate the heavy rainfall over Bangladesh region. Accordingly, we provided a heavy rainfall warning and its tailoring impact on agriculture and other industry, which was appreciated by the community.”

SERVIR Team Hosts Dialogue Workshop with Amazon Indigenous Communities

On June 9-10, SERVIR Amazonia supported Dr. Stephanie Spera’s Applied Sciences Team workshop, “Ecosystem Services and Socio-Environmental Dynamics Workshop in Indigenous Landscapes” in Breu, Peru. Spera’s co-I, Dr. David Salisbury (University of Richmond), facilitated the workshop with 120+ participants from more than a dozen indigenous communities across Peru and Brazil. Participants provided feedback on online dashboards developed by Spera and Salisbury’s team at the University of Richmond to help communities in the Southwest Amazon monitor forest conditions, evapotranspiration, and other environmental changes. This event was followed by a second workshop, ‘Southwestern Amazon Transboundary Corridors and Ecosystem Services Workshop’ in Pucallpa, Peru, held June 13-18.



Figure 24. Asheninka and Yaminawa representatives discuss maps from the SERVIR Applied Sciences Team while attending the conference in Breu, Peru on June 10. (Photo: Jake Ramthun, SERVIR)

On December 13, the SERVIR Amazonia hub and the AST team led by Dr. Spera (University of Richmond) launched the series of ‘geodashboards’ monitoring ecosystem services in the Southwestern Amazon. Built in consultation with indigenous communities in Peru and Brazil, these resources provide decision-makers with detailed information on changing weather and ecosystems in their region. The launch event was attended by stakeholders from Peru and Brazil and representatives of various indigenous communities in the transboundary Peru-Brazil region. Future meetings with the communities were planned to continue strengthening the integration of the dashboards in their work.

ARSET training survey response

“I think the continuous availability of such training will bolster our knowledge and practical applicability of these approaches, thanks to NASA, particularly for making the training accessible. Otherwise, from a developing country’s perspective, you have put us on a global level as far as knowledge in this thematic area is concerned. This is the true globalization of knowledge!!” *Survey comment, Participant of ARSET training, “Disaster Assessment Using Synthetic Aperture Radar” (October 2022) – NGO employee, Uganda.*

DEVELOP Arizona Water Resources

Pinyon-juniper woodlands (PJW) are a vital habitat and food source for hundreds of species and a source of both utility and cultural importance for Indigenous groups. In 2021, an extensive juniper mortality event occurred at Wupatki National Monument in Arizona during a decades-long drought. The National Park Service (NPS) partnered with NASA DEVELOP team at Goddard Space Flight Center for a two-term project (spring 2022 and fall 2022) to assess PJW tree mortality in Flagstaff, Arizona utilizing aerial imagery and NASA Earth Observations.

During the spring 2022 term, the team mapped PJW mortality and analyzed its relation to stand density, climatic and topographic variables in north-central Arizona between 2015 and 2021. To identify the extent of PJW, the team performed an unsupervised classification using National Agricultural Imagery Program (NAIP) data with validation sources including NPS-created land cover maps, Landscape Fire and Resource Management Planning Tools (LANDFIRE), NPS and United States Forest Service (USFS) vegetation maps, and Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) data. Using Terra Moderate Resolution Imaging Spectroradiometer (MODIS), Global Precipitation Measurement (GPM) Integrated Multi-satellite Retrievals for Global Precipitation Measurement (IMERG), Soil Moisture Active Passive (SMAP), Shuttle Radar Topography Mission (SRTM), and Landsat 8 derived Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) data sources, the team analyzed factors contributing to pinyon-



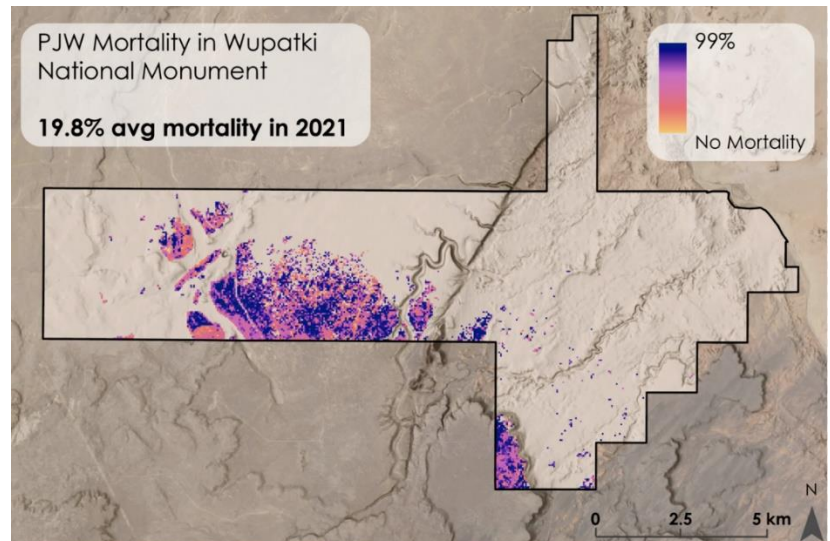
*Figure 25. Pinyon pine mortality.
Photo by US Forest Service, Southwestern Region.*

"Pinyon juniper woodlands are an important component of the landscape, ecologically and culturally. Pinyon juniper woodlands support a variety of wildlife species, especially mammal and bird species.... Loss of pinyon juniper woodlands threatens the ecosystem."

- Dr. Nicole Ramberg-Pihl, former DEVELOP Fellow

juniper mortality. Although no relationships were found in the broader study area, elevation, soil moisture, and land surface temperature were weakly related to PJW mortality within Wupatki National Monument. Results from this study provided insights that can inform NPS vegetation management practices to preserve natural resources and culturally significant sites.

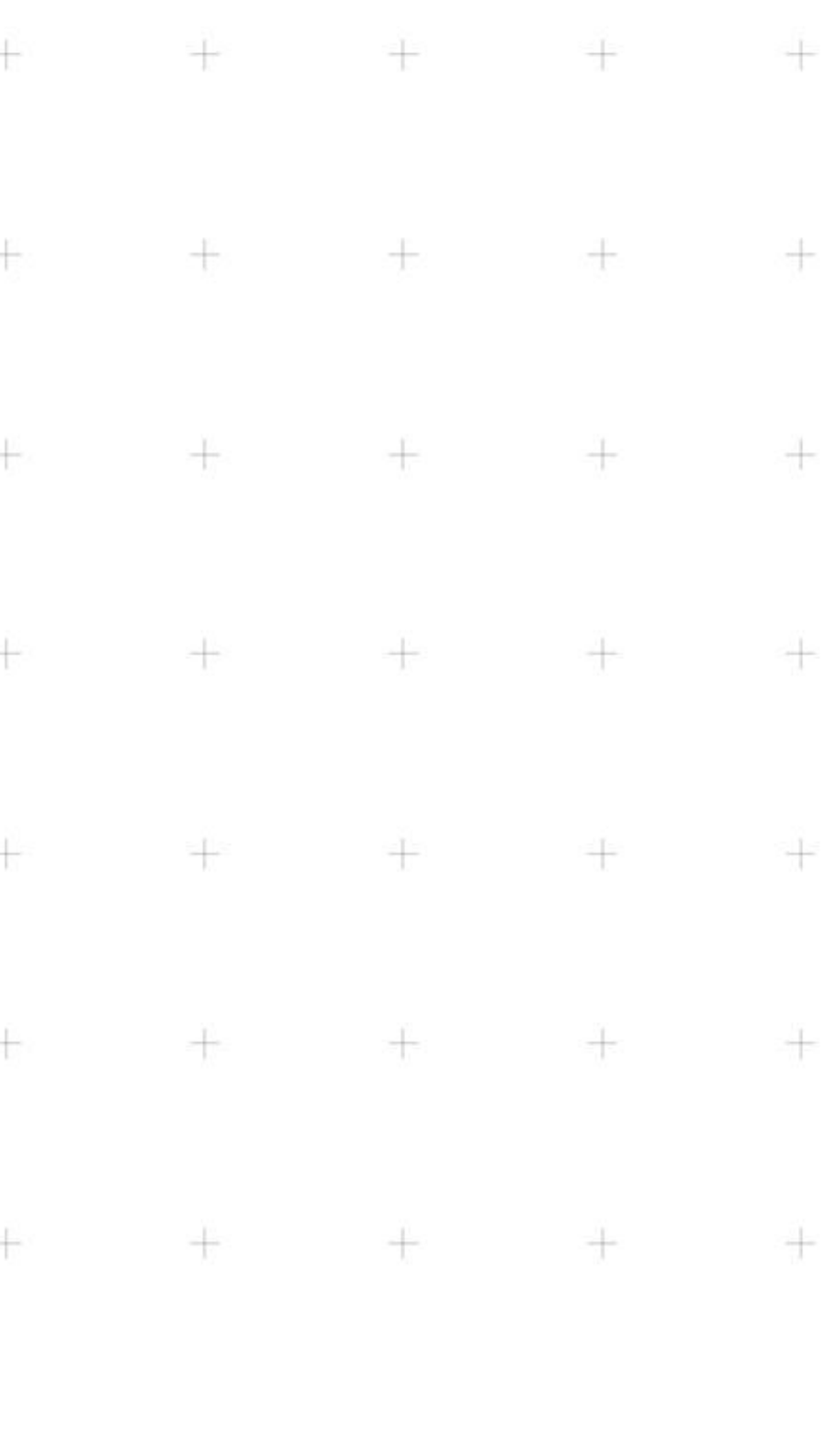
In fall 2022, the project continued and aimed to improve the previous term’s methodology and expanded the comparison of the post-mortality event in 2021 to include pre-mortality events in 2017 and 2019. In this iteration, the team utilized NAIP imagery in conjunction with LANDFIRE to calculate the total difference in PJW mortality using an unsupervised classification model trained from the Modified Soil-Adjusted Vegetation Index (MSAVI) and the Visible Atmospherically Resistant Index (VARI) of the study area. The research also focused on uncovering correlations between tree mortality and environmental factors using the Western Land Data Assimilation System (WLDAS) modeled climate data. Average PJW mortality from 2015 to 2021 was 21.63%, including 19.8% in Wupatki National Monument, with the vast majority of dieback occurring between 2019 and 2021. Although the interactions are weak, the most correlated variables included bare soil evaporation (0.15), rainfall (0.14), groundwater storage (0.13), and wind speed (0.12), indicating that drought is a likely driver of mortality.



→ *Fast Fact*

DEVELOP engaged **285** participants, **27** Fellows and Senior Fellows, and over **150** partner organizations, while conducting **71** projects impacting **37** states and **20** countries.

This DEVELOP work was highlighted on [Arizona Public Radio](#) through an interview with Dr. Nicole Ramberg-Pihl, former DEVELOP GSFC Fellow. Nicole spoke about juniper die-off in Northern Arizona and the team’s partnership with the National Park Service. This work was also presented at the 2022 16th Biennial Conference of Science & Management on the Colorado Plateau & Southwest Region.



LOOKING AHEAD



Challenges

Despite meeting many important goals, CBP experienced several setbacks and challenges throughout the year. In January, the in-person retreat was cancelled due to yet another COVID surge, and the team had to pivot to an entirely virtual retreat. As a program, CBP has struggled to find the right way to engage with other application areas and NASA programs, and to smoothly communicate, coordinate, and collaborate within the Earth Science Division. CBP piloted a number of approaches this year, including the portfolio reviews and various approaches at program reviews to narrow in on what works and what does not. Finally, CBP has found it challenging to balance priorities when engaging with various interagency and international networks, such as CEOS and GEO, with our core work. The EOTEC DevNet pilot has helped to ameliorate that challenge.

DEVELOP is migrating back to more in-person projects, although a stream of virtual projects will continue to be offered. The Program Office is still working to clarify opportunities on the online application site, as there was a skew in the spring 2023 applicant data, where 89% of the applications selected a virtual work environment as their preference and only 11% selected in-person. This made the virtual opportunities much more competitive since there were fewer virtual project opportunities. DEVELOP is actively working to balance the projects with applicant work environment preferences, as well as the Fellows leading in-person and virtual nodes.

One challenge ARSET continues to face is long-term, publicly accessible data storage. ARSET provides advanced trainings that are typically accompanied by step-by-step exercises that allow participants to download and analyze data. Various solutions were enacted, yet a more permanent solution remains a challenge. After explosive growth in recent years, participation seems to have leveled off in 2022. However, despite this, ARSET still reached over 2800 new organizations in 2022.

The EEJ area is still quite new, and the team experienced challenges due to lack of staffing in 2022. Assignment of a program manager and associate program managers in the latter part of the year were crucial to getting this element off the ground and will enable significantly more work to be completed in 2023.

Throughout the early part of 2022, constraints to travel and in-person meetings due to lingering COVID-19 restrictions continued to present some challenges to the SERVIR team, but by July, members of the network (including ASTs and Subject Matter Experts) were able to significantly increase in-person training events, stakeholder engagements, and tool launch/handover events in hub regions. SERVIR is also facing a challenge of valuable personnel accepting opportunities in the private sectors or with other programs.

One of the primary challenges for the Indigenous Peoples Initiative is that there is so much to be done in Indigenous engagement, and although the team is passionate and dedicated to this mission, there are often time limitations due to a small part-time staff. In addition, the team is asked to engage in activities beyond the core activities defined by the program. The team aims to connect the dots between NASA researchers, other federal agencies, Tribal professionals, researchers, nonprofit entities, etc., but have been doing so without additional resources. Meaningful engagement with Tribes takes a lot of time – often more than what is expected or planned for.

It is a challenge to balance agency interest with the needs of Tribes so as not to place undue strain on communities. Engagement has often been approached in a way that can be overwhelming and extractive for tribal communities. Additionally, with federal mandates, all agencies are showing up at once with their own agenda to fulfill. IP strives to center Tribal voices and needs in this process.

P&C identified several challenges related to team capacity, limited resources, and operational efficiency. It is a challenge to secure subject matter expertise or funding for the development of a prize or challenge. There can also be a mismatch of expectations from stakeholders who assume that the program can take a broad programmatic goal or priority and execute a prize or challenge on the topic of interest. Increased interest in open innovation projects means that the area has limited ability to respond to urgent requests for support.

Goals and Opportunities

CBP has had an exciting year not only with our traditional elements but also in the incorporation of our Community Action elements. We look forward to continuing to communicate, coordinate, and collaborate across our larger group of elements. For example, DEVELOP EJ projects and EEJ projects can synergistically help underserved communities. SERVIR work in the global context may be useful to domestic EEJ communities and vice versa. Our rescheduled in-person CBP retreat this spring will review the state of each of our program elements, review progress on creating Theories of Change for each element, explore cross-CBP collaborations, and discuss what we've learned about coordination across Applied Sciences and how we might improve further. We look forward to continued engagement across ESD as we embrace open source science, and as we transform to increase our impact.

In addition to the online webinar training, ARSET will be adding self-paced asynchronous training options using a Learning Management System (LMS). The first course to be offered will be on the Applied Sciences Program's

Applications Guidebook and is scheduled to open in Spring 2023. Future use of the LMS will include hosting ARSET's Fundamentals of Remote Sensing, and all thematic Fundamentals of Remote Sensing (Water Resources, Disasters, etc.). ARSET will conduct its first airborne-focused training in Spring 2023. This unique training will focus on the use of hyperspectral data, a theme highly requested in course surveys. Additionally in 2023, ARSET will build into its evaluation and outreach activities a focus on underserved communities, allowing the program to better understand the needs of these communities and inform future training development. ARSET will continue training on new datasets and topics to support future missions (e.g., PACE, TEMPO), and expand the climate and resilience trainings to include sea level change and adaptation. ARSET is adding an instructional designer to our program who will assist in developing and improving strategies and methodologies for both live and self-paced course delivery techniques.

In 2023, the P&C team is eager to complete the Tick Tick Bloom Competition and initiate transition and testing of winning solutions. They will also launch the Women's Aqua Boost Crowdsourcing Project, select and initiate planning for the Data Centers Energy Solutions Competition, and continue two open innovation research projects and publish results. To advance program continuity, the team will develop a P&C Partnership Strategy with SMD Partnerships Office and Office of General Council and a Communications Strategy with Applied Sciences Communications Team, and post competition stories on the Applied Sciences Website. P&C will also initiate a second iteration of the NASA Earth Science in Action Comic Strip Contest. Finally, the team aims to determine a Knowledge Management and Operational Strategy, which will include intern on-boarding resources, "cost-sharing" model for P&C project management, and project selection criteria.

The EEJ team will be growing in 2023 with the addition of five associate program managers and the first intern cohort expected in Spring of 2023. This team will manage the funded projects and begin to grow the program beyond these projects, including running a second solicitation through ROSES in 2023. The team will identify gaps in the current portfolio, develop external and internal communications materials (including a website, newsletter, and reporting metrics), and will conclude the first round of landscape analyses that were selected as part of ROSES A.49. The team plans to attend numerous meetings and conferences, including a spring meeting organized by the Deep South Center for Environmental Justice and the Hampton Roads Social Justice Conference, in addition to settings such as the American Meteorological Society Annual Meeting (AMS), the American Association of Geographers meeting (AAG), and the AGU Fall Meeting.

In the framework of SERVIR's ongoing Carbon Pilot (S-CAP) work, SERVIR and SilvaCarbon will jointly deliver a training January 17-18 in Guatemala, focusing on land cover change methodologies. SERVIR Mekong will launch a new phase and re-branding to SERVIR Southeast Asia on January 24, in a ceremony that will include U.S. Ambassador to Thailand Robert Godec and NASA Earth Science Director Karen St Germain, expanding its

geographic reach to include more of the Association of Southeast Asian Nations. The fourth Applied Sciences Team will hold their official Kickoff in Huntsville, Alabama, February 7-9. Selected through the 2021 ROSES Solicitation, these AST members will support SERVIR's efforts to co-develop meaningful geospatial tools for communities in Asia, Africa, and Latin America for the next three years. Another important event for 2023 is the launch of SERVIR Central America as the sixth SERVIR hub, planned for late in the year.

Looking ahead to 2023, the SERVIR network will continue to work to integrate the SERVIR Strategic Plan for 2020-2025 into SERVIR services. The Interagency Agreement between USAID and NASA continues this unique global initiative for the next five-year period (2021-2025), with a vision looking towards 2030. SERVIR will continue to engage in activities dedicated to strengthening sustainability and accessibility through sharing of open-source software, promoting inclusivity through the Global Gender Strategy, the Gender Analysis Tool, and GAIINS and Advancing Women's Prosperity activities, and promoting scientific diplomacy through a commitment to key initiatives like PREPARE and the Forest Data Partnership.

Through the strategic planning process, the IPI team has developed 4 strategic goals which will lead the team into the 2023 year:

Goal 1: Cultivate knowledge sharing pathways around the use of Earth Observations (EO) for Indigenous community action within landscapes

Goal 2: Strengthen the capacity for the use of NASA EO data and tools for Indigenous community action

Goal 3: Uphold and share respectful and reciprocal engagement strategies across NASA Earth Science for Indigenous community action

Goal 4: Increase presence of Indigenous people at NASA to diversify worldviews within Earth Science

The team plans to coordinate two in-person workshops with a regional focus (in the Southwest and Great Plains) to conduct regional needs assessments around the use of EO in Indigenous communities. The team will continue to support EEJ projects with an Indigenous focus, and plans to support a number of trainings and workshops, including Tribal GIS, GEO for Good, Indigenous Mapping Workshop Australia, Indigenous Mapping Workshop Canada, and a training with the Karuk Department of Natural Resources. The team will continue to support GEO and US GEO Indigenous Engagement and will focus on relationship building and outreach to communities and the broader NASA community.

APPENDIX



EARTH SCIENCE
APPLIED SCIENCES

Acronyms

AAG	American Association of Geographers	LANDFIRE	Landscape Fire and Resource Management Planning Tools
AGENT	Advancing Gender in the Environment	LMS	Learning Management System
AGU	American Geophysical Union	MAIA	Multi-Angle Imager for Aerosols
AMS	American Meteorological Society	MAIANSE	Minority University Research and Education Project (MUREP) for American Indian and Alaska Native Science, Technology, Engineering and Math (STEM) Engagement
AQ	Air Quality	MODIS	Moderate Resolution Imaging Spectroradiometer
ARSET	Applied Remote Sensing Training	MSAVI	Modified Soil-Adjusted Vegetation Index
ASP	Applied Sciences Program	NAIP	National Agricultural Imagery Program
AST	Applied Sciences Team	NDMI	Normalized Difference Moisture Index
CBFEWS	Community-Based Flood Early Warning System	NDVI	Normalized Difference Vegetation Index
CBP	Capacity Building Program	NICFI	Norway's International Climate and Forests Initiative
CEOS	Committee on Earth Observation Satellites	NPS	National Park Service
CEPREDENAC	Coordination Centre for the Prevention of Natural Disasters in Central America	NRCS	National Resources Conservation Service
CSA	Canadian Space Agency	OLI	Operational Land Imager
DEIA	Diversity, Equity, Inclusion, and Accessibility	P&C	Prizes & Challenges
E&SA	Eastern & Southern Africa Ecosystem Spaceborne Thermal Radiometer Experiment on the International Space Station	PJW	Pinyon-juniper woodlands
ECOSTRESS	Equity & Environmental Justice	PUP	Pop-up Projects
EEJ	Earth Science Data Systems GIS Team	ROSES	Research Opportunities in Space and Earth Sciences
EGIST	Environmental Justice	SCO	Science Coordination Office
EJ	Earth observations	SEA	Southeast Asia
EO	Earth observation training, education, and capacity development network	SMAP	Soil Moisture Active Passive
EOTEC	Earth Science Division	SRTM	Shuttle Radar Topography Mission
DevNet	Earth Science Data Systems	STEM	Science, Technology, Engineering, and Math

GAIINS	Gender-sensitive Agricultural Index-based INSurance	STMD	Space Technology Mission Directorate
GEE	Google Earth Engine	TEMPO	Tropospheric Emissions: Monitoring of Pollution
GEO	Group on Earth Observations	TES	Tropospheric Emission Spectrometer
GEOBON	GEO Biodiversity Observation Network	TIRS	Thermal Infrared Sensor
GEOGLAM	GEO Global Agricultural Monitoring Initiative	TIRS	Thermal Infrared Sensor
GEOGloWS	GEO Global Water Sustainability	TOPS	Transform to Open Science
GFOI	Global Forest Observations Initiative	UNDP	UN Development Programme
GIS	Geographic Information Systems	UN-SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response
GPM	Global Precipitation Measurement	USAID	The United States Agency for International Development
HIWAT	High Impact Weather Assessment Toolkit	USDA	United States Department of Agriculture
HYDRAFloods	Hydrologic Remote Sensing Analysis for Floods	USFS	United States Forest Service
ICRISAT	The International Crops Research Institute for the Semi-Arid Tropics	USGS	US Geological Survey
IMERG	Integrated Multi-satellite Retrievals for Global Precipitation Measurement	VARI	Visible Atmospherically Resistant Index
IMW	Indigenous Mapping Workshop	VEJ	Virtual Environmental Justice
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs	WCS	Wildlife Conservation Society
IP	Indigenous Peoples	WGCapD	Working Group on Capacity Building and Data Democracy
IPI	Indigenous Peoples Initiative	WLDAS	Western Land Data Assimilation System

Earth Observation Assets Employed by CBP

ALOS-1 PALSAR	ISS ECOSTRESS	Sentinel-1 C-SAR
ALOS-2 PALSAR-2	ISS GEDI	Sentinel-2 MSI
Aqua AMSR-E	Jason-2 Radar Altimeter	Sentinel-3 OLCI
Aqua MODIS	Jason-3 Radar Altimeter	Sentinel-3 SLSTR
Suomi NPP ATMS	Landsat 4 TM	Sentinel-5P TROPOMI
Aura OMI	Landsat 5 TM	Sentinel-6 Michael Freilich Radar Altimeter
CALIPSO CALIOP	Landsat 7 ETM+	SMAP L-Band Radiometer
ENVISAT MERIS	Landsat 8 OLI	SMOS
ER-2 Jet AVIRIS	Landsat 8 TIRS	SRTM
GEMS	Landsat 9 OLI-2	Suomi NPP VIIRS
GeoEye	Landsat 9 TIRS-2	SWOT
GEOS-5	MUSES DESIS	TAMSAT
GOES-16 GLM	NISAR	TanDEM-X
GOES-East	OCO-2	Terra ASTER
GOES-West	OCO-3	Terra CERES
GOSAT	PeruSat-1	Terra MODIS
GPM IMERG	Planet Dove	TerraSAR-X
GPM LIS	Planetscope	TOPEX/Poseidon
GPM TMPA	PRISM	TRMM TMI
GRACE	Quickbird-2	Worldview-2
GRACE-FO	RadarSat Constellation Mission	Worldview-3
Himawari-8	RadarSat-2 SAR	
IceSat-2 ATLAS	RapidEye	
IKONOS	SAOCOM-1	

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**Please visit our website to learn more
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<https://appliedsciences.nasa.gov/what-we-do/capacity-building>

Background Image: Milwaukee Urban Development

NDWI-processed image in the aftermath of a rainstorm in Milwaukee, Wisconsin.

Created by Lisa Sun, Annika Harrington, Jack Acomb, Madeleine Tango, Remi Work.

Source: Landsat 7 ETM+.

